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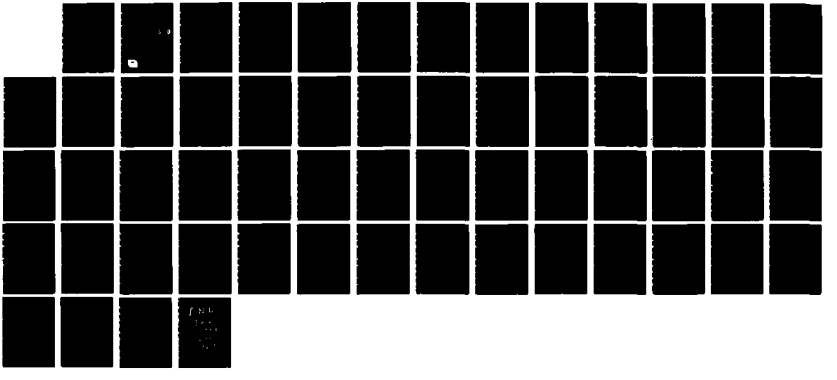

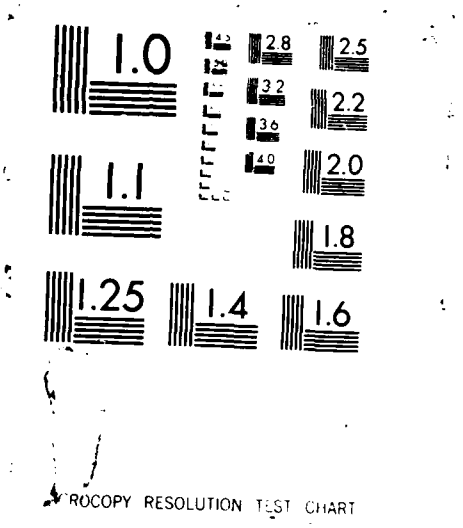
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IDA MEMORANDUM REPORT M-137

AN ASSESSMENT OF THE STARS PROGRAM SEPTEMBER-OCTOBER 1985

Volume II
TECHNICAL BRIEFING

Elizabeth Bailey
Richard DeMillo
Herman Fischer
Patricia Greene
John Kramer
Sarah Nash
Thomas Probert
Samuel Redwine
William Riddle
Robert Winner

December 1985

Prepared for

Office of the Under Secretary of Defense for Research and Engineering

INSTITUTE FOR DEFENSE ANALYSES
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The STARS Program Plan, September 19, 1985, is reviewed and analyzed. An IDA panel finds that the plan is a reasonable starting point, but finds problems in the areas of management, theme, strategy, execution organization, and in several of the STARS Area plans. The two major points are that the STARS program requires strong central direction with a controllable organization and strong clients and that a theme of marketplace stimulation rather than technology development should be adopted and made to permeate the program.

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TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF FIGURES

1.0 INTRODUCTION

At the request of the Software Technology for Adaptable Reliable Systems (STARS) Joint Program Office (SJPO), the Institute for Defense Analyses (IDA) undertook a review of the STARS Program during September and October of 1985. Three concerns prompted the review: (1) the Program is to receive $42 million in FY86, (2) the perception that STARS is not effective, and (3) the absence of an effective top-down plan for the Program.

The following review panel---consisting of IDA staff and consultants---conducted the review:

Dr. Elizabeth Bailey (Software Metrics Inc.)
Dr. Richard DeMillo, Georgia Institute of Technology
Mr. Herman Fischer (Mark V Business Systems)
Ms. Audrey A. Hook (IDA)
Dr. John F. Kramer (IDA), Chairman
Dr. Thomas H. Probert (IDA)
Mr. Samuel T. Redwine (IDA)
Dr. William Riddle (Software Design & Analysis, Inc.)
Dr. Robert I. Winner (IDA)

Some of the reviewers have worked on IDA tasks for the STARS Program for several years; others have consulted occasionally on STARS; and a few had no prior exposure to the Program. This mix helped provide a more balanced perspective on the subject.

Another group was briefed on the progress and findings of the panel at a meeting on September 26, 1985; this group consisted of the following members:

Mr. Joseph Batz
Dr. Barry Boehm
Mr. Bill Carlson
Dr. Neil Eastman
Mr. Joseph Fox
Dr. Ugo Gagliardi
Dr. Leonard Haynes
Dr. Ed Lieblein
Dr. Edith Martin

Many of these reviewers were subsequently contacted on an individual basis regarding specific areas of concern. In addition, the panel's preliminary conclusions were briefed to the Defense Science Board panel headed by Fred Brooks on October 23, 1985. The comments and advice received during these briefings were quite helpful in shaping the panel's findings.

This review proceeded in several stages:

(1) The first stage was a discussion and analysis of the origins of the STARS Program and the events leading up to its current state.

(2) The panel then attempted to understand the internal and external organizations and activities relevant to the STARS Program. This included both the technical and political aspects of these organizations, as well as their inter-relationships.

(3) The panel then assessed the most recent STARS plan (19 September 1985) [1]. The assessment concentrated on:

a. The Program's goals expressed in the plan

b. The earlier goals as analyzed in the STARS Goals and Objectives Working Group report [5]

c. The goals for the six STARS organizational areas (as stated in the plan)

d. The plans for the six areas (as reported in the August 1985 Quarterly Briefing)

The panel found the September 19 plan a reasonable beginning toward aiming the Program in a positive future direction. In general, problems are reflected in disparities among the general goals and strategies expressed in the plan and the details of the rest of the plan, the current area activities, and the current Program organization.

These problems are explored in this report. A brief history of the STARS Program is presented in the next Section to provide a context for understanding the panel's conclusions. In Section 3, an overview of the panel's major findings is presented, followed by a detailed discussion of these findings in Section 4. The panel's recommendations are recapped in Section 5, and a brief synopsis of the panel's assessment appears in Section 6.

2.0 HISTORY OF STARS

The impetus for the STARS Program can be traced back to an April 1979 statement to Congress by Ruth Davis, then the Deputy Under Secretary of Defense for Research and Advanced Technology. She announced that the Department of Defense (DoD) would launch a software technology initiative. Planning for the Program itself began in FY80-81 when the Office of the Secretary of Defense (OSD) used their study fund to plan for a DoD "Software Initiative." A workshop was held in Raleigh, North Carolina in FY83 during which the original proposal for the STARS Program was presented. The general goals for the program were announced to be to improve the productivity, quality, and predictability of DoD software.

Originally, the Program comprised nine areas: Human Resources, Acquisition, Human Engineering, Application-Specific, Project Management, Support Systems, Systems, Measurement, and Technology Transition (the Software Engineering Institute).

In FY83 STARS received $2 million funding from the Defense Advanced Research Projects Agency (DARPA). Congress limited FY84 funding to $1 million because it felt that STARS was not adequately justified as a program ([6] summarizes the arguments of need and rationale for the STARS program). An additional $4 million was reprogrammed from the Army and a plan was developed to disperse the funds. This plan was published in March of 1984 and a task force was formed to elaborate the plan and begin its execution.

At this time the nine STARS areas were reduced to six. Project Management and Acquisition were combined. Technology Transition was seen as deserving of special attention under a separate program. Human Engineering was distributed into the Human Resources and Support Systems Areas. Support Systems was divided into a Software Engineering Environment Section and a Methodologies Section that incorporated the Systems Area and the Ada Joint Program Office (AJPO) Methodologies Project. Teams, composed of volunteers, were formed to plan accomplishments for each of the six resulting technical areas.

In FY84 a third new STARS Director was appointed. The STARS Director and the service managers from the Army, Navy, and Air Force attended a retreat in July 1984, and there shifted the STARS Program emphasis to the implementation of a Software Engineering Environment (SEE). The technical area teams were told to produce a six-year plan and fit their projects into the context of

the new STARS emphasis. The upper management of the program was now operating by committee and consensus.

Up to this time, committee members had been mainly volunteers, paid by their home organizations. Beginning in FY85 their salaries were paid by STARS, but they were still employees of their various agencies. To date, Area committee members are federal employees.

Because of continuing management problems, the Program Director resigned and was replaced. The new acting director started just in time to attend a STARS meeting in Virginia Beach, Virginia, in February 1985, where some progress was made on developing the program. Although the Services voiced strong support of STARS at a subsequent 1 May 1985 meeting in San Diego, California, program management problems continued and increased into September of 1985 when the priority of the issue was elevated to the level of the Under Secretary of Defense. The Director, Computer Software and Systems, asked the SJPO to have an assessment of the value and future of the program performed. The basis was to be the September 19, 1985 STARS plan.

3.0 SYNOPSIS OF THE PANEL'S FINDINGS

The panel's assessment of the STARS Program is outlined in this Section and discussed in greater detail in Section 4.0. While the panel found the major problems as discussed in these two Sections, it should be emphasized that the panel also felt that the current plan and the current state of the program are adequate starting points for arriving at a desirable and beneficial future for the STARS Program.

First, the panel found organizational and management problems related to accountability, consensus, spending authority, and contracting. The panel feels that the Program cannot succeed with the current committee management approach. Although OSD, Computer Software Systems Directorate (CSSD), and SJPO management have consistently opposed a committee approach, they have not been successful in avoiding the diffusion of authority now found in the Program. The panel recommends a strong centralization of authority and accountability with associated spending and contracting capabilities.

Second, the panel found that the STARS Program has in the past consistently lacked an appropriate, unifying theme. The panel feels that the Program cannot reach required levels of organization without such a theme. Working back from an assessment of the desired post-STARS situation, the panel developed a STARS Program theme that would achieve its vision of the future. In short, this theme and vision entails the fostering and assuring of the continued existence of competitive marketplaces in software engineering tools, methods, and practices and in Mission Critical Computer Resource (MCCR) software. The theme is a modification of the current theme in which the Program's emphasis is shifted away from building environments and toward stimulating the marketplace so the Government and its contractors can buy all or part of the environments they require.

Third, the panel assessed each Area's goals, plans and activities, as described in the 19 September Program Plan and the August Quarterly Briefings, and found incompleteness, inconsistency and a lack of coordination. These problems stem primarily from the absense of strong top-down direction within the context of a unifying theme. The panel used its suggested marketplace-based theme to identify several possibilities for improvement in the Areas' plans. Most of these improvements fall within the scope of the SEE Area for which the panel suggests a major strategic re-adjustment.

Finally, the panel found major problems in the Program's execution and again used its suggested marketplace theme to identify several actions that can be taken to spark execution. The panel feels that those existing tasks consistent with the marketplace theme should be continued or

accelerated, and that other tasks should be adjusted, or terminated. In addition, the panel feels that attention must be rapidly brought to bear on obtaining intensive industry involvement in STARS activities.

4.0 DETAILS OF THE PANEL'S FINDINGS

This section presents the panel's findings with respect to the STARS Program's management, strategy, and technical areas. Included with the findings are summaries of specific recommendations for improvement.

4.1 Management

Management problems are the most critical ones that STARS must solve. These problems start at the top of the organization with an OSD/Tri-Service committee arrangement that has proven unable to provide the objective, timely decision making, the consistency, and the direction needed for development and execution of an integrated program. Administrative problems---particularly delays in transferring funds---have complicated these problems. Uncertainties regarding appropriations have added to these delays with the result that awarding contracts and beginning effective execution have been significantly delayed. The management problems therefore span the full range of the Program's management.

STARS is a joint Program needing extensive coordination and cooperation, but sound, proven management principles require that the Director be given the authority to accomplish the job. A permanent Director must be appointed immediately and given the recognized authority to institute top-down planning and control and to eliminate management only by consensus. The Director needs the authority (and "political power") to set directions for, organize, manage and administer the Program.

The sometimes paralyzing OSD/Service conflicts over distribution of authority must be resolved. This will require attention at management levels above CSSD and SJPO. Once these conflicts are resolved, the STARS Director can institutionalize the arrangements required to provide effective Program planning and execution. Undoubtedly, a number of organizations throughout the Services will be involved. Formal arrangements according to each Service's practices should be established to ensure proper lines of responsibility.

To effectively support the resulting centralized management, administrative, and particularly financial, processing must be organized and swift all along the chain. Effective administrative processes need to be established for contracting, tracking disbursements, preparing plans, reviewing plans, and reviewing accomplishments. While the higher-level management issues are more important, these administrative processes are essential to an effective STARS program.

In addition, there must be an effective line management organization. This implies that the execution organization should be different from the organization previously used for planning. It also implies the appropriate, facilitating, official arrangements must be made with and within DoD Components. A line organization with clear execution authority and accountability is critical to the Program's success. Under the current STARS organization, the Director has no line authority over Service Program Managers, their Deputies, or Area Coordinating Team (ACT) leaders (see Figure 1). A line management organization with clearly defined managerial and technical responsibilities must be established. Individuals should have clear objectives for which they are held accountable. The organization should reflect a well-structured program with a hierarchical division of responsibility.

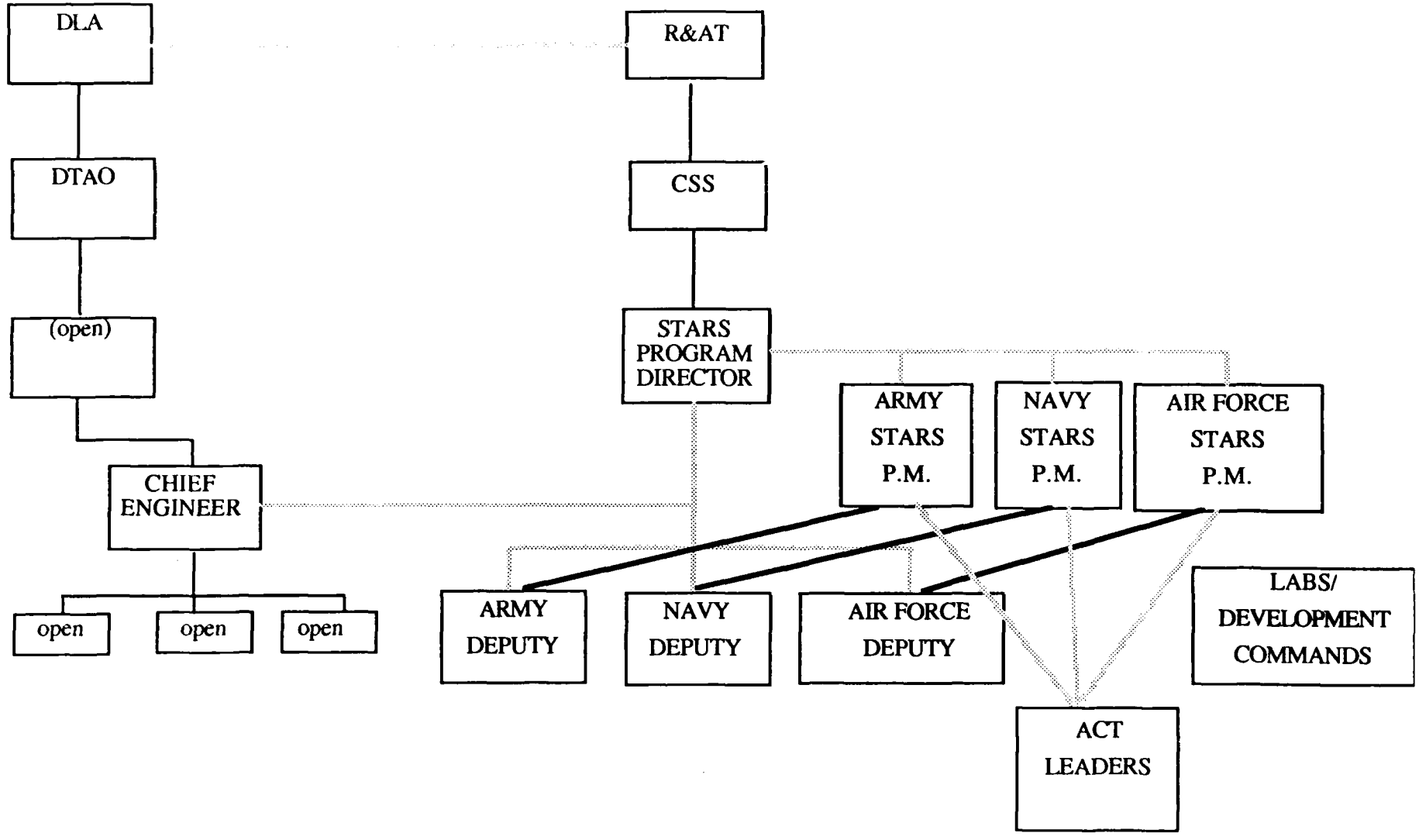

FIGURE 1. STARS Current Organization

With respect to the role of the Technical Area Teams within a line organization, the panel recommends that these become adjuncts to the individuals (and project offices) managing the Areas. Their role should be advisory and technical. Steps should be taken to ensure their competence in this technical role. Over time, the emphasis in some areas will shift from development to insertion. As this happens, the membership of the teams may also need to shift to ensure the best mix of expertise.

Management attention will be a scarce resource, and STARS management needs to define the critical success factors and critical-path activities where it should concentrate its attention. To do this, the STARS strategy must be clearly defined. This strategy should then be provided as guidance to other levels in the Program. One of the most critical factors is technical quality, and the Director should take steps to provide an appropriate review mechanism to help ensure this quality.

Finally, the Director must move rapidly to establish effective lines of communication and synergy within the Program and between the STARS Program and other programs and activities. Effective communication and coordination mechanisms must be established among the Area Managers and Teams to improve integration and exploit success. Technology transfer, marketing and execution relationships with other Programs and activities must be institutionalized to establish a customer base for the STARS Program, forestall duplication, and establish an accurate "public" perception of the Program.

The panel identified three alternatives for restructuring STARS management to assist in accomplishing some of these changes in program management and administration. Management Structure Alternative One is close to the current structure and therefore would result in little perturbation of the existing structure (see Figure 2). However, because the bubbles at the bottom are individuals rather than committees or teams, this alternative has the problem of inverting rank among Deputies and Service Program Managers and the panel thought it could be improved. Management Structure Alternative Two increases the SJPO to a dimension more suitable to the Program's size (see Figure 3). It also divides the Program into two segments, Technology Development and Use, introducing the latter to explicitly address the insertion of technology. Management Structure Alternative Three is a refinement of Alternative Two that was suggested as a result of one of the panel's briefings to its reviewers (see Figure 4).

These alternatives are offered in a positive attempt to make more concrete the relatively abstract recommendation to form a line organization for the STARS program. Hopefully, the real organization, when formed, will be even better and reflect the many concerns that need to be addressed---without, of course, abandoning the principle of having a truly accountable line organization.

4.2 The Desired Situation After STARS

Understanding the panel's observations and recommendations regarding the Program's strategy and technical areas requires an understanding of the panel's "vision" for the future. The panel's view of the future emphasizes the marketplaces for DoD-related software. It articulates the required characteristics of the post-STARS situation and the results of STARS in terms of the marketplaces for software tools and methods as well as end-use MCCR software. For the most part, this vision is related to mission, economic, organizational, and acquisition concerns rather than technical concerns. The panel felt that all of these aspects are essential to the success of the STARS Program.

The ultimate goal must be to contribute to ensuring the ability to build and support the DoD's mission critical systems of the early 1990's. While doing this, the basis must be established for meeting the requirements in the years beyond. STARS is intended to be a program of finite length ending with the institutionalization of the improvements it has fostered and a suggested process for further improvement.

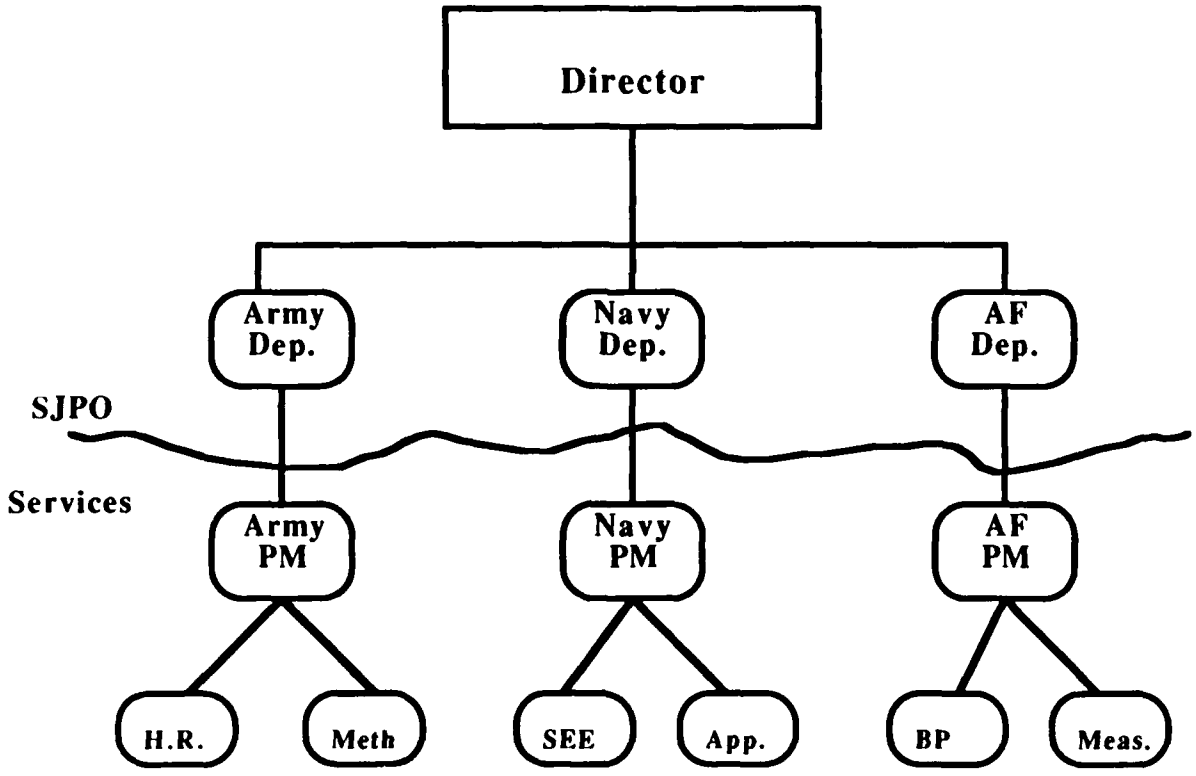

Figure 2. Management Structure Alternative One

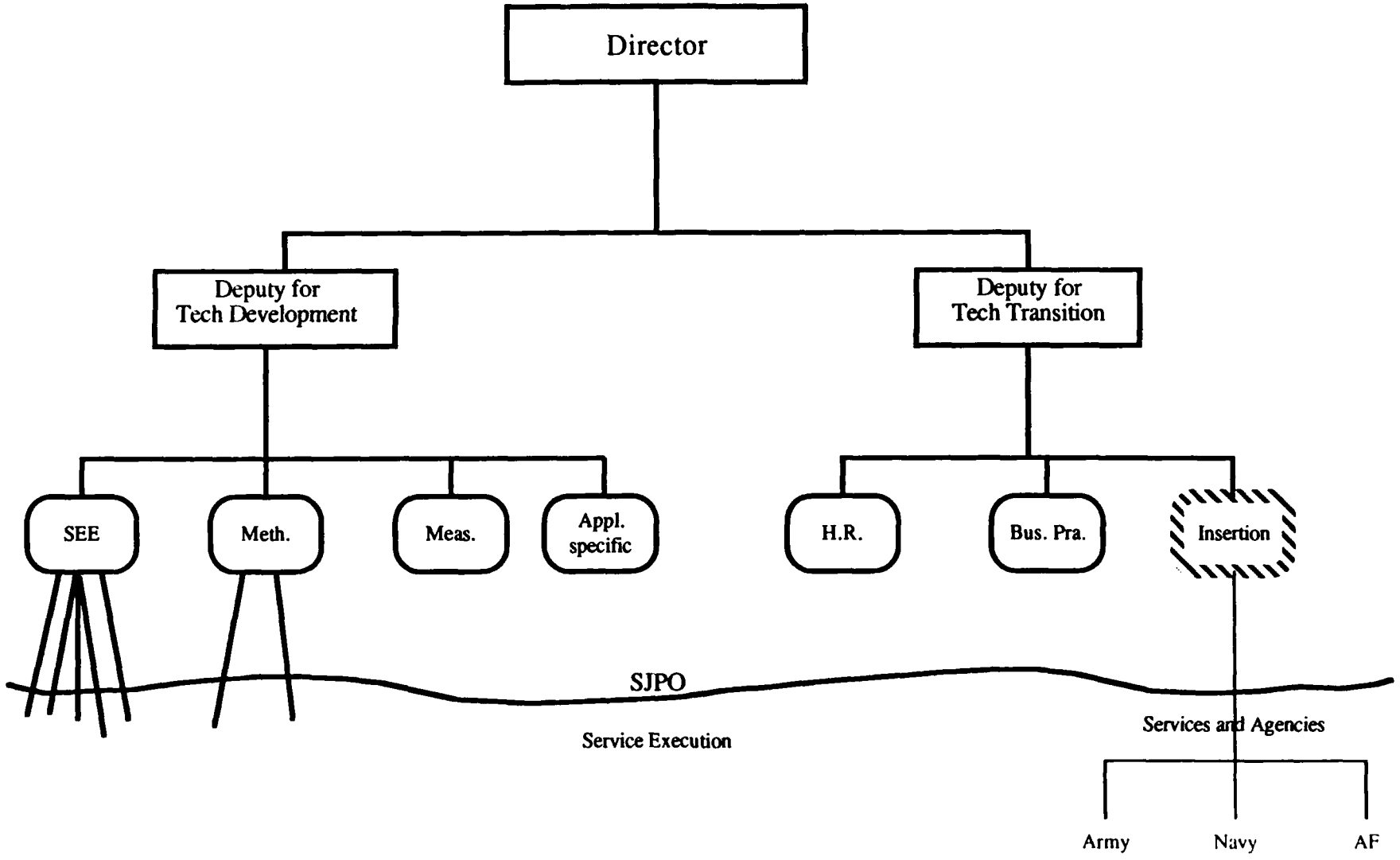

Figure 3. Management Structure Alternative Two

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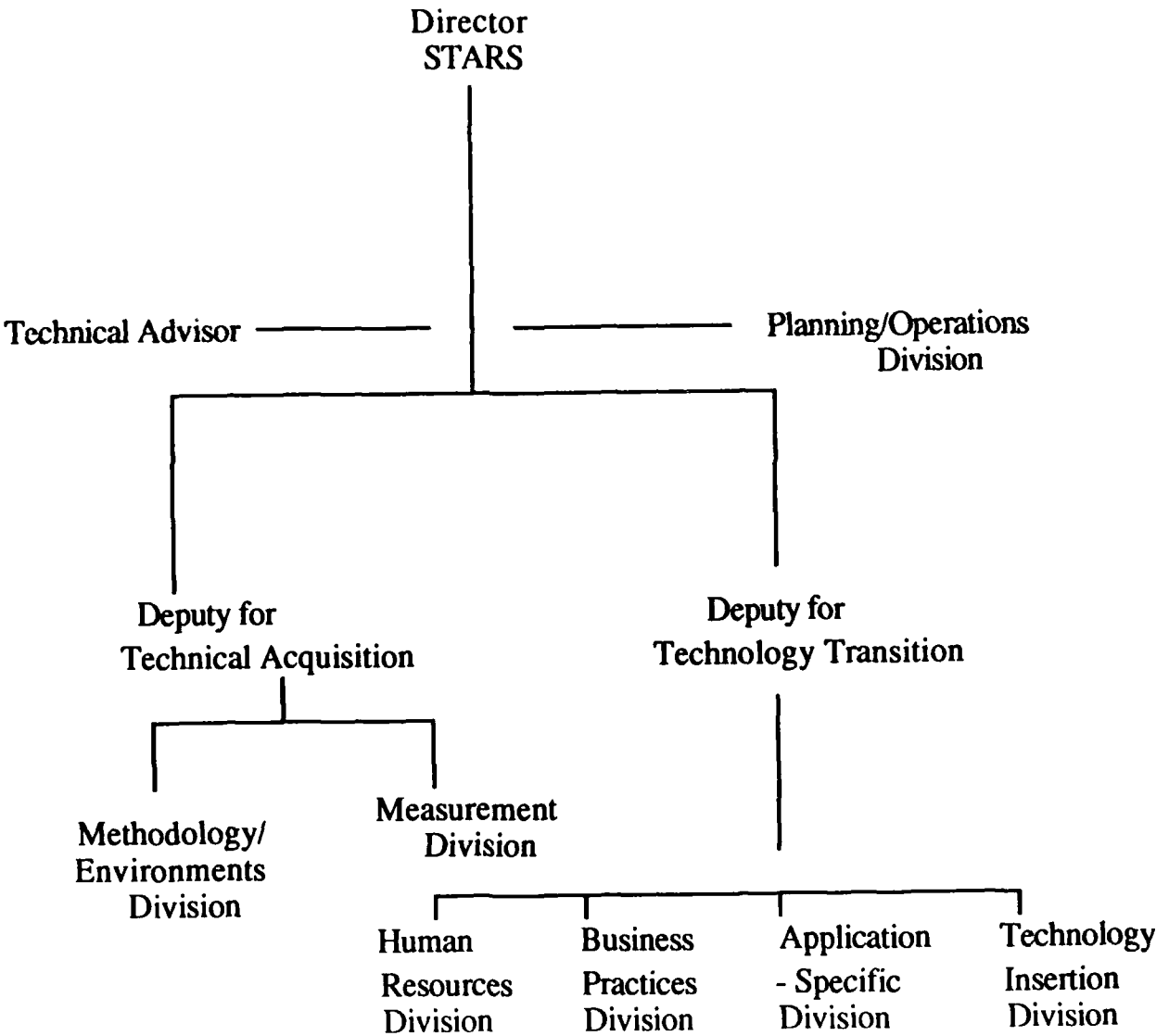

Figure 4. Management Alternative Three

Mission critical systems requirements imply MCCR software requirements that in turn imply requirements for the future software state-of-practice within the DoD community. To achieve this required state-of-practice, the necessary technology must exist and it must be successfully used throughout the DoD community. Extensive, successful use will require sufficient numbers of competent persons in the community plus effective support for comparative evaluation of alternatives, successful and speedy introduction of new technology, and propagation of the technology throughout the community.

With these goals in mind, the panel identified fifteen requirements for the situation after STARS (see Figure 5). The most important requirements are intelligently establishing software requirements and then efficiently moving to meet these requirements. The exact degree of necessity or desirability of the other thirteen is arguable, but the panel felt they were all at least strongly desirable.

STARS needs a vision of how the defense community should operate in the mid-1990's to develop and support MCCR software within the context of these requirements. The panel believed that this vision should be along the lines of that in the rest of Section 4.2.

The defense community will be well ahead of potential adversaries, improving rapidly to stay ahead, and maybe even widening the gap. Defense software will be meeting its requirements with the needed quality, on time, for reasonable cost -- and doing so predictably. To do this, technology will be flowing rapidly into use throughout the DoD community regardless of its commerical, academic, or Government origin. Facilitating this will be a regulatory context that fosters the needed investment by providing an equitable return for all (including the Government) and a compatibility-based marketplace for the technology, particularly as it is embodied in software tools and in reusable MCCR software.

Key to the functioning of the tools' marketplace will be standardized interfaces among environments that allow transfer of (at least) work products, and (at most) all types of software tools and users. These standardized interfaces will be accompanied by acquisition guidelines, certification tests, and processes for development. The resulting high degree of compatibility will provide a basis for the marketplace's success and the cumulative improvement of the whole community while allowing competitive advantage to be obtained by true innovation rather than by "re-inventing the wheel." Among other things, the compatibility will ease the transfer of software to logistics organizations and potentially provide significant cost avoidance because of the reuse of software across DoD programs.

Each DoD contractor will be able to exercise a range of options from having his own unique environment, with only the ability to exchange work products with other environments, to having a completely compatible environment. Those contractors using environments that are compatible with the standard interfaces beyond the work product level will have the significant advantage of being able to acquire (and also to lease and sell) conforming tools in the marketplace. This variety of situations will allow a range of Government Furnished Equipment (GFE) rather than contractor-furnished approaches to Government acquisition of end-application software.

DoD will be an intelligent buyer of software and an investor in software technology. The marketplace will be broad and the Government will be able to obtain the best software and software technology, perhaps obtaining different pieces or services from different vendors. Every project will be able to rapidly establish an appropriate environment, or rapidly modify its existing environment, to meet the needs of and constraints upon the project. It will also be possible to rapidly produce initial and subsequent versions of MCCR software. Productivity and quality levels will be greatly improved over the present MCCR software situation.

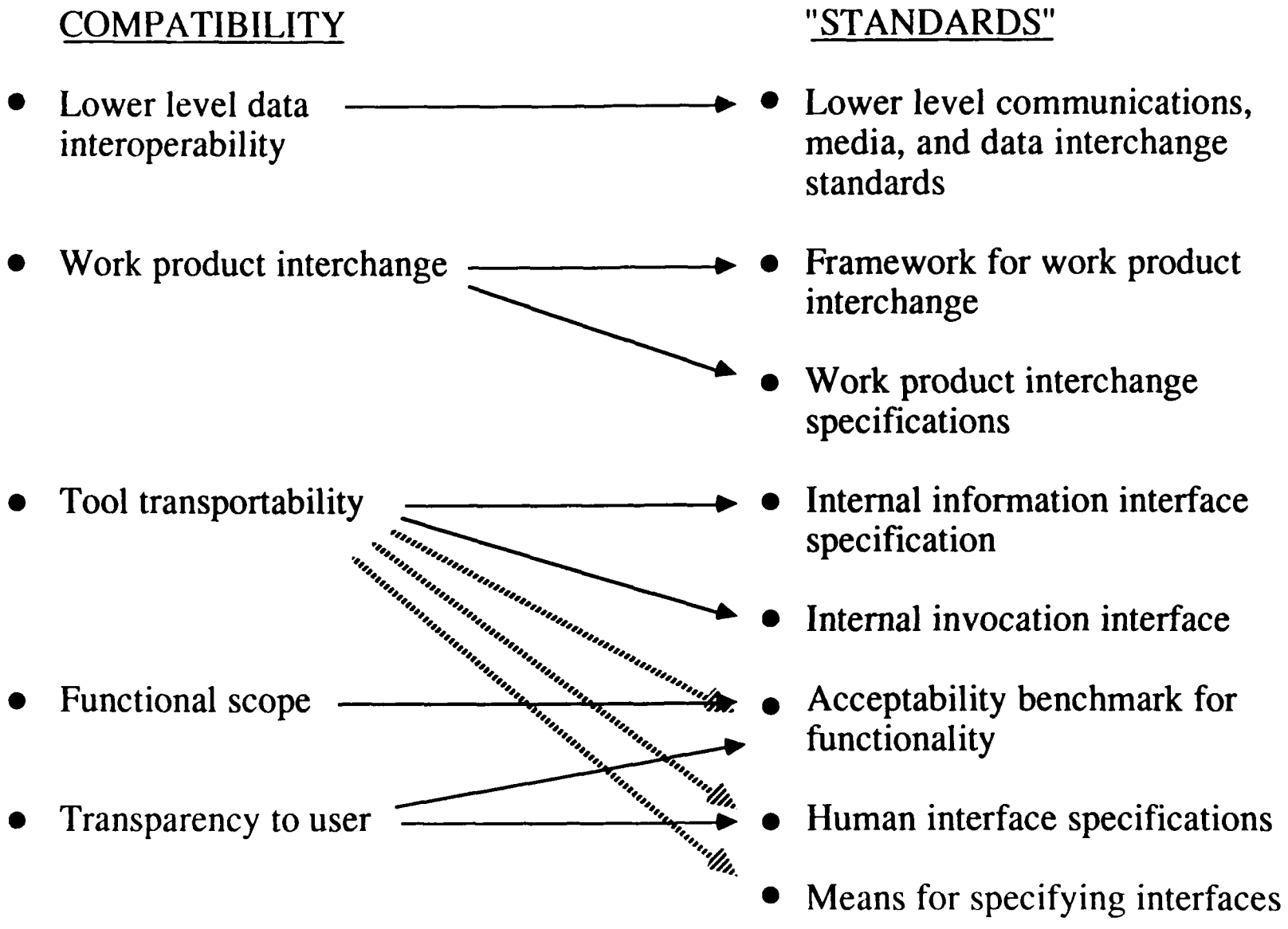

Figure 5. Interfaces for STARS "Standardization"

4.3 Program Strategy

The Program's general strategy, as presented in the 19 September Program plan emphasizes the development and propagation of software technology. The strategy reflects a "Software Environments" theme under which all activities focus on developing improved environments and their more wide-spread use [7]. As a result, the Program's activities and organization emphasize technology research and development.

The vision of a future world presented in the previous section suggests a marketplace theme for the STARS program. This theme has, as its central characteristic, the Government-led development of competitive marketplaces for both MCCR software and the methods and tools for creating and evolving this software. Under this theme, attention must still be directed to improving software technology and to the extent of its use. Still, the marketplace theme shifts attention to exploitation of marketplace mechanisms to achieve initial improvement and provide for continued improvement.

It is the panel's judgement that a marketplace theme is considerably better for meeting the STARS Program's goals. This conclusion was reached after considering the implications of the requirements for the future world discussed previously, considering various alternatives for creating this world, and factoring in the panel's understanding of the industrial and political situation in the U.S.

The following section analyzes the Program's current general strategy. Then it discusses the suggested marketplace theme: what it is; why it is valuable; and how it can provide an implementation strategy for the STARS program. Finally, recommendations are made for several execution-related actions that must be taken to turn the program in the right direction.

4.3.1 Current Program Strategy

The general strategy reflected in the 19 September program plan has three key aspects. First, management is centralized within OSD. Second, there is a focus on several key technology improvement/insertion issues: automation of software creation and evolution, reuse of software components, use of advanced design technology, standardization, acceleration of technology transition, improvement of DoD business practices, and the creation of a large and capable work force. Finally, the Program is organized along traditional technology development subject areas.

The major problem is that this strategy does not address establishing a basis for continued improvement---it focuses on an initial (and significant) improvement in capability without direct attention to further improvement. By focusing on the end to be achieved rather than the means for achievement, the strategy directs the Program's attention to technology research and development without capturing and preserving the process by which improvement can be obtained.

4.3.2 Proposed Marketplace Strategy

Based on the requirements for the panel's envisioned future world, its understanding of the industrial/political situation surrounding the STARS program, and a consideration of various alternatives, the panel concluded it would be best to base the Program's strategy upon the exploitation of marketplace mechanisms. The panel felt that such a strategy would lead to the needed near-term improvement being sought as a direct effect of the STARS program and also provide the basis for continued improvement being sought as an indirect effect.

The marketplace theme causes STARS to focus on fostering a competitive supplier community for the tools, processes and end-application components needed to produce and maintain software meeting DoD requirements. The intent is to foster marketplaces in the underlying

technologies needed to meet the requirements for DoD software in the near-term and the future. While active DoD involvement and some DoD investment will always be required, STARS should think in terms of establishing a situation where DoD state-of-the-practice software technology and end-application software needs are naturally, quickly and cost effectively met via free-enterprise marketplaces.

Two related marketplaces must be created, each presenting distinct inherent requirements. Establishing a marketplace for tools and processes requires achieving high degrees of compatibility, significant private sector investment, government acquisition policies/practices that contribute rather than inhibit, and the active use of comparative evaluation mechanisms. Establishing marketplaces for end-application components involves creating a number of marketplaces for the different applications areas---markets with mainly one buyer, DoD. The solutions to problems such as rights of data may differ from solutions to the same problems in the tools marketplace because of DoD's role as dominant consumer of MCCR products.

Several characteristics are desirable for both types of marketplaces. The products available in the marketplaces should cover the full software system life span. The products should not just stress and support the automated aspects of software production and creation but they should also address other aspects; courses intended to improve human skills, for example, would be a reasonable marketplace product. Finally, the marketplaces should admit a variety of options with respect to GFE policy towards products.

Several other national software technology programs (e.g., ESPIRIT, Japanese Fifth Generation) have recognized the value of a marketplace-based strategy that emphasizes industry involvement in both producing an initial improvement in software technology and participating in a free-enterprise marketplace to provide continued improvement. The benefits of using this strategy for the United States' program include: (1) attraction of private-sector investment, (2) attraction of expertise outside of that obtained by direct contract, assurance of product support, and (3) development of a partnership rather than adversary relationship with industry.

In the remainder of this Section we discuss the Marketplace Theme, its perceived value and ideas for its creations in greater detail. We also demonstrate how the Marketplace Theme can provide a strategy for STARS and how it can be implemented and executed in the program.

4.3.2.1 Marketplace in Software Engineering Tools and Methods

This marketplace concerns the technology used to create and evolve software. The products within this marketplace pertain to the tools and methods that software practitioners (both in and outside government) use to produce and maintain MCCR software systems. Creating this marketplace requires solving several, primarily technical, problems. Chief among them is providing for technical compatibility through standardized interfaces. Attracting investment from the private sector, instituting appropriate acquisition policies/practices, and providing a comparative evaluation cabability are the other key issues.

4.3.2.1.1 Technical Compatibility

There are a variety of different ways in which we can think about compatibility among software engineering environments . Five major ones are:

(1) Lower level data exchange. This encompasses basic data communication mechanism and media (e.g., magnetic tape) compatibility between collections of tools. It can relate to anything from mail and file transfer to the transfer of database contents, possibly even based on a fairly high-level model such as the entity-relationship model.

(2) Work product exchange. This refers to the degree to which a full set of software related work products, in machine readable, manipulable, and analyzable form, can be transferred between tool collections. This potentially includes all the deliverables called for by DoD-STD-2167 and other standards, plus required-but-not-deliverable products and other work products.

(3) Tool transportability. This can concern a variety of issues from moving self-contained tool sets to moving an individual tool that works effectively with many other common tools, services, and data. Tool transportability requires the definition of both information and invocation interfaces. Among these interfaces are those pertaining to the operating system; the data management subsystem; the human interface management subsystem, and to generic tools and tool fragments.

(4) Functional scope. Two tool collections may differ in the functionality they provide. They may overlap completely or there may be relatively little or no overlap. Functional scope compatibility is important when considering whether two environments can be combined or used in tandem.

(5) Transparency to users. This concerns the degree to which differences in tool implementation or installation are hidden from the user. This can be important not only for users to be able to easily move from project to project but alsowhen considering the compatibility of the user aids (e.g., documentation, manuals, etc.) transferred along with work products or tools.

While couched in terms of tool compatibility, it should be understood that the remarks apply equally to the compatibility of the methods supported by the tools. For example, methods can be more or less compatible with regard to user transparency, depending on the degree to which insignificant definitional details (perhaps only pertinent to implementing the supporting tools) are hidden from the user.

The most obvious interfaces are external, information-oriented ones; obvious in that they pertain to the information flow between an environment and the world outside the environment. Interfaces will also be needed for information structures internal to an environment, including: interfaces for lower level work products internal to the environment (e.g., an annotated data flow graph); prominent inter-tool interfaces that may not be work products (e.g., DIANA); specifications used as input to tool generators; specifications of scripts or procedures; and specifications of guidance and assistance information such as used in on-line tutorials and help documents.

Information interfaces pertain to the structure and content of the information flowing across a boundary. Invocation interfaces are needed as well; these interfaces specify the ways in which control can be passed back and forth across the boundary over time. There are a variety of candidates for invocation interfaces in a typical environment; among them are the interfaces to the database subsystem, the human interface subsystem, the operating system, the communications subsystem, and generic tools or tool fragments (e.g., invocation interfaces to editors and compilers). These and other invocation interfaces are discussed in the Integration and Compatibility Framework Section of the Operational Concept Document [4]. The Common APSE Interface Set (CAIS) effort will continue to address the operating system invocation interface, but other efforts (or an expanded CAIS effort) are needed to adequately address all of the issues involved.

Ensuring the desired high levels of compatibility requires not only rigorous interface specification, but also criteria, metrics, and evaluation and certification capabilities. In addition, the interface definition process must capitalize on future technological improvements as well as provide

for extensibility. Finally, some degree of standardization may be required (at least at the defacto level), along with other actions by the Government, in order to bring the desired levels of compatibility into existence and mature them over time.

Figure 6 shows several different types of standards implied by the differing types of compatibility discussed above. Lower level data exchange directly implies the need for at least one path (e.g. magnetic tape, data communications) between environments meeting the time, volume, and security requirements for a given exchange. Work product exchange implies the need for a framework for the elements being transferred and specifications for the individual information fragment types and their interrelationships. Tool transportability implies standardization of the formats for information in the database or passed between tools and the invocation interfaces used by the tools. Less directly, tool transportability depends on consistency in the delivery of the functionality required by the tools and consistency among the human interface, documentation and help facilities. Consistency in functional scope, if desired, could be enforced using a standard acceptability benchmark. User transparency implies at least similar human interfaces and available functionality. Also of interest, both for achieving consistency in general and for facilitating the use of tool generators, are the notations and processes available for specifying interfaces.

4.3.2.1.2 Other Key Issues

In addition to interfaces supporting technical compatibility, establishing a marketplace in software engineering tools and methods requires: (1) the attraction of private-sector investment, (2) the development of appropriate acquisition policies and practices, and (3) the provision of a comparative evaluation capability. The Business Practices Area must focus its attention on these issues.

Private sector investment. It is unreasonable to expect that taxpayer money will be used to underwrite all the improvement that will be needed; investment from the private sector must be actively pursued. Small investors and innovative firms can be attracted if they can enter the marketplace with a low-investment product that will work compatibly with other products found in the marketplace. In addition, the larger the marketplace, the more attractive it will be to investors and firms at all levels. Technical compatibility beyond just the DoD community can thus be beneficial to DoD.

While competition among suppliers is healthy, DoD will benefit most if investors build on each other, rather than duplicate each other. The majority of products in the marketplace should therefore be small-scale ones that can be used in a variety of situations on a mix-and-match basis. In addition, the practice of adding value to existing products should be routine and extensive.

Uncertainty will scare off private sector investment. DoD can help alleviate this uncertainty by doing the research and development to demonstrate feasibility. It can also help by removing the uncertainty from its own future marketplace-related actions and policies. (For example, an announced commitment to buy in the future in a certain fashion can be a powerful motivator for potential suppliers.) The Government needs to form a pattern of procurement requests for products using well-defined criteria, and industry needs to feel that the definition is stable enough so as not to void industry investment. The Government should then:

(1) Insist on compatibility in all related procurements (even hardware).

(2) Use financial and other incentives to speed compliance; use metrics to better ensure results and compliance.

(3) Emphasize compatibility and currency of technology in RFP evaluation criteria.

- Intelligently Establishing Software Requirements
- Meeting DoD Software Requirements (Functionality, Amount, Resources, Time, Quality, Predictability)
- Having Software Capability Lead Over Potential Adversaries
- Rapidly Improving Software Capabilities
- Rapid Technology Flow in U.S. Defense Community, Regardless of Origin
- DoD Leveraging Investments from Outside
- Significantly Reusing Defense Software
- Fairness to Taxpayer
- DoD Technology Base Efforts Soundly Organized
- Capability in Place at DoD Software Logistics Centers
- Ability to Transfer Software for Logistics and to Avoid Contractor Lock-in
- Ability to Accommodate Range of DoD Component GFE Policies
- Ability to Accommodate Range of Contractor Make/Buy Strategies and Compatibility
- Educating Students in Software Engineering-Related Studies Prepares Them for DoD Preferred Technologies
- Ability to Accommodate Direct and Military Foreign Sales

Figure 6. Requirements For Situation After Stars A-20 BSH11/85-37

Acquisition policies and practices. As indicated the Government's acquisition policies and practices should remove uncertainty from the marketplace as much as possible. In addition, these policies and practices should serve to create demand in the marketplace, lead to the Government obtaining better MCCR software, accelerate technology insertion, and accomo-date a range of GFE policies. Creating improved acquisition policies and practices will require:

(1) Definition of an underlying, uniform interface model supporting independent tool development and integration.

(2) Definition of the commitments required of a vendor (support levels, documentation, performance standards, etc.).

(3) Regular identification of a "shopping list" of automated tools and methods (based, in part, on assessments of valuable future technology).

(4) Provision of an evaluation and certification service as well as vehicles forintegrating the tools and methods into the STARS environments and the marketplace.

Also, issues related to rights in data, software licensing and mixed ownership must be studied with respect to their effects on the marketplace.

Comparative evaluation capability. Tools and methods products will be successful in the marketplace only if they are of production quality and are fully supported. The consistent use of metrics across the community will allow developers and the entire market to readily judge new products and interpret reported experience with older ones. This will require an evaluation capability that relies on measurable characteristics, helps in certifying new marketplace entries, and assists in comparing among the various alternatives that will emerge. For the sake of time, the DoD may need to supply its own evaluation capability.

4.3.2.2 MCCR End-Application Component Marketplace

The products appearing in this marketplace are components of MCCR software systems. The technical problems discussed for the software engineering tools and methods marketplace are pertinent here. Many of the mechanisms and changes developed for the Tools and Methods Marketplace will be useful in the Component or Generator marketplaces. Therefore, these mechanisms and changes must be prepared with a concern for the MCCR Marketplace as well. Each application marketplace can be expected to have fewer suppliers and only a few buyers.

In addition, a number of non-technical issues make the development of this marketplace complex, especially as it relates to reusable software. These issues include: classified software; proprietary interests; rights in data (e.g., derivative works); undesirable foreign technology transfer; libraries; warehousing; cataloguing and retrieval; support; incentives; royalities; and making software a recurring business. Many of these issues have received attention, but much more effort is required before they are solved entirely. The Business Practices and Applications Areas will be particularly critical in this regard.

4.3.2.3 Desirable Marketplace Characteristics

Both types of marketplaces must exhibit several characteristics. First, the products must collectively span the full software life cycle, covering all activities from initial conception to final retirement. And the products must not merely be (closed-system) implementations; definitions and designs must also be available.

Second, the marketplaces must exhibit concern for the people who will use the technology This means that the products must be accompanied by appropriate documentation and that training and education products should be present in the marketplaces.

Third, the marketplaces must admit a wide variety of options with respect to the issue of GFE. Different parts of DoD have (and will probably continue to have) different policies regarding provision of software engineering environments and tools. Some desire to supply them to the contractor and some prefer to give the contractor complete freedom (and responsibility) to use whatever he wants. In practice and in theory a whole spectrum exists between a strict GFE requirement and total freedom.

The panel identified several pros and cons of this spectrum's end-points. Arguments for GFE include improved maintenance and interoperability while opponents of GFE argue that GFE is costly, contributes to receiving low quality products, and presents a delay in the insertion of new technology into the community. On the other hand, proponents of total freedom, supported by competitive marketplaces, argue that this leverages captial, naturally selects for quality, and incrementally inserts technology. Issues of control, interoperability, and compatibility argue against the competitive marketplace end of the spectrum. The panel had strong beliefs regarding this subject but recognized that STARS cannot (and should not) dictate policy on this issue.

The panel observed that the issue of GFE is really totally separate from the issue of whether or not STARS should adopt the suggested marketplace theme. DoD could GFE products regardless of whether they come from the marketplaces or are developed "in-house." Thus, any decisions regarding GFE do not affect (or negate) the recommendations presented here for implementing and executing the STARS Program under a marketplace-based strategy.

4.3 2 4 Why the Marketplace Theme is Important

The theme of creating and using marketplaces is important because it lays the foundation for continued, evolutionary improvement toward the envisoned future world discussed previously. It helps to meet the following requirements for this future world: attracting and leveraging private-sector investment; fostering a high degree of portability for software tools; speeding the flow of technology into wide-spread use; and supporting the reuse of software system components.

Several other national software technology improvement programs have emphasized government/industry cooperation for their programs. The different cultures surrounding these other programs have led to details that differ from those suggested here. However, the sense is somewhat the same -- use Government influence to shape and prime the ways that software and software technology are acquired. Within the context of the American system, this intent rather naturally leads to a marketplace-based strategy that exploits the capabilities of the U.S. industrial/political system. The marketplace theme is important in that it exploits an existing system to achieve its results.

Finally, the marketplace theme is important because it leads to direct and extensive industry involvement in STARS activities. Directly acquired products of the STARS program will be contracted under Federal Acquisition Regulations (FAR). FAR part 27 of the DoD FAR Supplement covers rights in technical data and software, and is very explicit; products (particularly software) developed with the Government's money are in the public domain. By developing products under private-sector investment, and letting the investors retain proprietary rights, industry should actively participate in achieving the Program's goals and objectives, with numerous benefits. Needed additional investment will be generated from outside STARS. The benefits of the American system (such as private initiative, competition, and the desire to make a profit) will be exploited. Industry understands the necessity to supply a fully supported product and is motivated to get its products used; a marketplace-based strategy will therefore foster both follow-on support for products and a

technology push from within industry. Finally, expertise other than that directly contracted for will be attracted to the solution of DoD problems.

4.3.2.5 Implementing the Marketplace Theme

Creating these marketplaces requires developing a customer base, a base of private funding, and a facilitating regulatory context. To do this through the STARS program requires a new implementation strategy that emphasizes market force exploitation and a focus on buying products rather than building them in-house. This implementation strategy, in turn, requires several immediate shifts in the execution of STARS Program. In this Section, we first discuss the creation of the marketplace in general and then propose specific implementation and execution strategies for STARS that foster marketplace creation. Again, this theme must permeate all STARS Areas, but the Business Practices Area should be the coordinating area for these issues.

4.3.2.5.1 Creating the Marketplaces

The primary issues in marketplace creation are: (1) creating customer demand; (2) creating supplier community interest, investment, and products; and (3) creating a favorable regulatory and policy context. Secondary issues are influencing the Program's primary customers and influencing the supplier community.

The Ada effort is an example of the synergism required and possible in regulatory, acquisition, and supplier policy to support the desired marketplaces. Market demand was created, or reinforced, by the letter from Dr. DeLauer that established an Ada policy (even though the letter basically only issued a revised policy draft for service coordination, and did not legislate that policy officially). Supplier activity started because of a void in programming language activities in DoD from the mid-1970's to early-1980's, and the perception by 1980 that the Ada language was going to be sufficiently successful for the DoD to demand its use. Regulatory synergism, and further fuel for supplier interest, came in the form of the Validation Test Suite for Ada. This device both assured venture investors that there was a way to measure the market suitability of their product, and provided customers with a form of assurance of product conformance. The original intent of the test suite was different, namely, to control the proliferation of language variants.

Creating customer demand. The primary customers for the software technology resulting from the STARS Program are DoD Program Managers. Creating customer demand therefore requires that the Program Managers be educated, legislated, and politically encouraged to require STARS-related products to be supplied, used and supported in their systems. Program Managers must be made to feel that they cannot do without the products, methods and practices resulting from the STARS Program. Education and assistance of Program Managers must then be a very high priority item. STARS can provide the assistance by demonstrating benefits, assuring the development of needed technology, and providing money for expert assistance, tool demonstrations, education, etc.

Creating supplier community interest, investment and products. This requires a perceived customer demand, a favorable regulatory and policy environment (to be discussed), and investor appeal. Investor appeal is needed because supplier business performance is measured, by the owners of the supplier's business, in terms of the degree of return on investors' capital (spent in creating the product and developing its market). Various approaches to assuring a return on investment should be investigated and the more promising ones should be actively "marketed" (along with the related factors discussed above) within the DoD community and software community at large.

Creating a favorable regulatory and policy context. Critical to the creation of a favorable regulatory and policy context is the resolution of FAR inconsistencies. The FAR secretariat is in the

process of re-issuing both civilian agency (and NASA) versions of the FAR and the DoD FAR supplement. These two regulations differ substantially in their definition of software, their delineation of data rights and private retention of software rights, and in the protection each offers to the developer (to protect supplier interests) and to the Government (to protect buyer interests). To achieve standardization and reusability in the software area, it seems necessary to consider parallel revision of these two regulations (as far as they pertain to software products which are likely to be common to DoD and non-DoD agencies, such as Ada-related tools and environment products).

Secondary regulatory issues concern DoD-level instructions and directives. These will probably require revision as determined by the Business Practices Area, and as determined by the Software Engineering Institute's (SEI) related investigations. Coordination between the STARS and SEI business practice activities is mandatory for success in this regard.

Influencing the Program's primary customers. In order to influence Program Managers, it is necessary to understand how they are motivated. Program Manager's are motivated by two levels of concerns: (1) their career and (2) their performance with respect to their current tasking as reflected by fitness reports. The first concern is related to career advancement, considering fitness reporting, superior satisfaction, and ability to move in a long-term direction. This can be in conflict with near-term tasking (project) performance, particularly where project performance optimization might require decisions that are politically dangerous. STARS management must be sensitive to the issue of risk reduction for Program Managers.

Because many DoD systems have several Program Managers prior to operational acceptance and several after initial fielding, there is a serious conflict between a single Program Manager's goals of delivering within cost and on time, and the long term program life cycle costs and risks. This second level of concern is relatively easy to cope with, as long as STARS-related needs are justified (proven) to the Program Manager (and reasonable in an absolute sense). Marketing STARS-related concepts is required. Reinforcement, following decision making, is also necessary to make a "sale" stay "sold."

Influencing the supplier community. This issue arises because STARS has a significant budget and its expenditures can significantly influence the marketplace. The SEE Area, with the largest budget portion of the STARS program, has the most possibility of influence. Environment-related expenditures, properly controlled to direct supplier attention to desired topics, should be a major focus. Significant attention should be given to desired supplier focus with regard to future environment-related purchases. This includes both topical areas of expenditure, as well as requirements levied on suppliers (such as in terms of standard interfaces).

If the 19 September Program Plan's strategy is followed, an additional consideration should be the breadth of marketplace coverage when procuring the six initial designs and the final two substrates. It may be necessary to either encourage suppliers to have a wide participation of subcontractors, or otherwise provide a larger number of smaller contracts. Section 4.4.3 on the SEE Area recommends the former. This is necessary to expand the market influence of SEE-related expenditures beyond two main SEE suppliers.

4.3.2.5.2 Implementation Strategy

The 19 September Program plan essentially proposes to do "business as usual," that is, develop large-scale products using existing DoD acquisition approaches. In this section, the problems with this approach are first identified and then several general principles to guide the development of a detailed implementation strategy are discussed.

The STARS Program cannot afford to conduct its business as usual. It is well-recognized that this approach is synonomous with cost overruns, low quality, and, in some cases, entire

systems never being delivered at all---STARS must expect that it may fall prey to these attendant problems. STARS must try out new ways of doing business or it will become another large, ineffective Government program, exhibiting all of the problems it is supposed to be helping to solve.

A disproportionate share of STARS resources are currently targeted toward the development of various technologies, particularly in the form of production-quality tools (a "build-it" approach). Instead, as discussed above, STARS should be stimulating the private sector to provide the needed technology including tools, methods, and reusable application components. STARS should also be helping to transform the DoD into an intelligent buyer of that technology.

One can look to the Ada Program to see the results of both approaches. The build-it approach has been employed by the Army and Air Force environment efforts (the ALS and AIE, respectively) and these efforts have encountered well-publicized problems in the area of costs, schedules, and performance. The market-stimulation approach has resulted in a number of efforts undertaken by private industry (e.g., ROLM/Data General, Verdix, Digital) that have met with considerably more success.

The market-stimulation approach has worked for the Ada Program because software vendors have had a reasonable degree of assurance that a market for Ada products exists. At the same time, the DoD has successfully maintained control over the language through the compiler validation process. The Ada Program can provide a model on a small scale of what needs to be done in the DoD on a much larger scale. There are many issues that are not understood at this point. Clearly, risk is involved but the alternative of "business as usual" is no alternative at all for a program intended to solve the problems caused by that very approach.

Rather than being in the business of developing tools, it should be the responsibility of STARS to be very clear about what it needs, that is, to provide clear and stable specifications. As much as is possible, these specifications should be expressed in an objective and quantitative manner. It should also be the responsibility of the STARS Program to develop mechanisms for determining adherence to any given set of specifications. This should serve as a model for DoD as a whole in procuring at least major portions of MCCR systems through the use of reusable application components. It should be left up to the marketplace to be innovative in producing the best products according to these criteria. The validity and reliability of the valuation and selection criteria are obviously critical if this approach is to succeed.

The role of each of the areas within STARS should be to develop rigorous specifications reflecting identified DoD requirements. In order to stimulate meaningful competition, these specifications and associated acceptance criteria must be made public. STARS should promote the explicit policy that the DoD, as a customer, will evaluate competing products on the basis of these criteria.

None of these marketplace stimulation-oriented implementation actions are simple; but all of them are critically necessary. The STARS Program will have to evolve a detailed Section. The panel feels that these principles have general utility and should be kept in mind during the development of any strategy for STARS implementation regardless of whether or not it adheres to the suggested marketplace theme.

Exploitation of marketplace forces. Since direct marketplace creation is impossible, the STARS program must indirectly shape and mature the marketplaces through its activities. First, STARS must estimate what the marketplace will provide of its own volition. After mapping this to estimated needs, STARS should move to construct, with its own resources, what is considered necessary and unlikely to be provided by the marketplace itself. Government-supported construction will prime the marketplace by convincing suppliers of feasibility and an established need. In addition, STARS should begin to rely, as early as possible, on the emerging marketplaces as much

as it safely can. To do this, STARS must be able to ensure that items that it plans on obtaining from the marketplaces are available when needed. This requires forecasting DoD software technology requirements and knowing the extent to which industry will be able to meet these requirements through its own activities.

Even if the suggested marketplace theme is not adopted for the STARS Program, then this principle still has some applicability. Forecasting needs and estimating future state-of-the-art technology should be performed regardless of the theme. Announcing needs and looking to external sources, rather than attempting to define and contract for technology to meet these needs, is an approach that can be successfully used by the DoD under a variety of themes.

Capitalization on other programs and activities. A second principle is to capitalize on other programs and activities as much as possible. A broad spectrum of external programs and activities need to be considered. The STARS Program is pervasive in that it will eventually involve all communities that use or develop software. These communities include DoD components, non-DoD Government entities, defense and commercial industry and their associations, and academia.

Management of a program involving so many players will be complex; it will demand careful consideration of the interrelationships and needs of these parties. The Council of Defense and Space Industry Associations (CODSIA) had a similar need to consider the total community. Their task, relating to reports 13-82 [2] and 21-83 [3], diagrammed the relationships among the concerned parties. Figure 7, derived from these exercises, shows the interrelationships as they relate to the STARS Program.

A detailed discussion of this Figure appears in Appendix A and only a brief synopsis, discussing the various types of parties, is included here. The STARS Program's external constituents include both STARS "partners" and STARS product and technology consumers:

- JLC/CRM (Joint Logistics Commanders/Computer Resources Management) Software Initiative. This initiative has developed and revamped (with the assistance of industry) software policy and software product standards for the services.

- MCCR Standards Master Plan. This plan attempts to catalog and categorize all DoD and non-DoD standards that apply to MCCR. Included are the voluntary standards organizations plans, as well as the more official sources of standards.

- Service Components. The Service Components include the Army, Navy, and Air Force. These organizations are the developers of the STARS products (by chairing work area teams and by managing industry contracts) and they also represent the consumers of STARS products and technology. Included in Service Components are computer resources management, defense systems acquisition, and operational users.

- Industry components. The industry components include industrial companies,industrial organizations, and professional organizations with a primarily non-Government membership.

- Standards bodies. These include those professional and industry organizations that define and evolve standards relating to software creation and evolution.

- Technology transfer agents The SEI is the primary organization responsible for transferring the technology developed as a result of the STARS Program. Workshops and conferences also play their traditional roles in effecting this transfer.

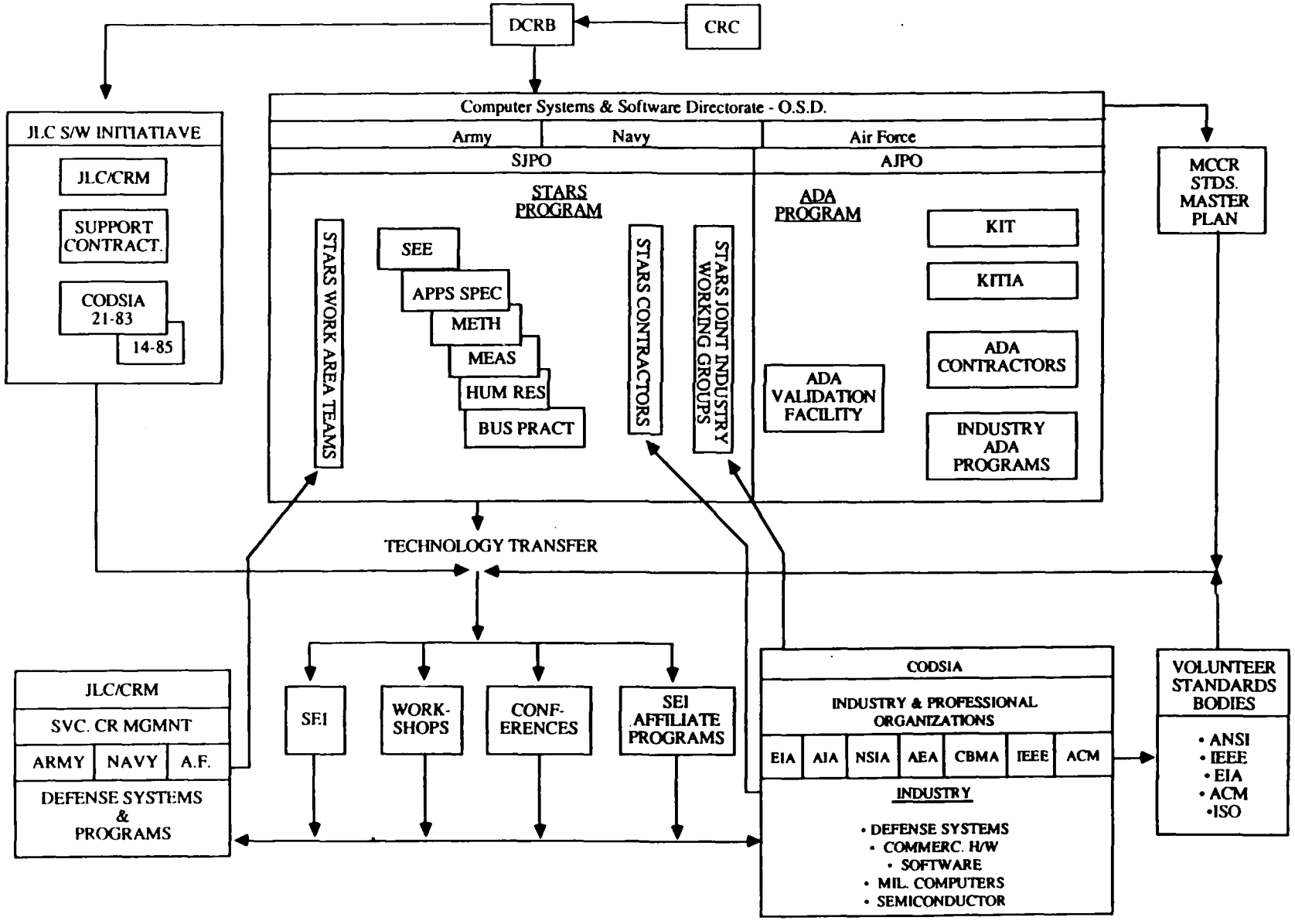

Figure 7. Technology Transfer Relationships and External Constituents

Focusing on critical success factors. The final principle discussed is to focus management attention on critical factors. Every program must identify a set of critical success factors and track their applicability and the degree to which they are being met. This has never been done for the STARS Program. Some factors---such as the appearance of standard interfaces---can be inferred from the 19 September Program Plan, but an explicit list is not given in that plan. Under a marketplace-based strategy, additional, more-concrete success factors can be delineated.

Historically, neither the Raleigh Workshop nor any Program plan to date has addressed critical success factors. At the Raleigh Workshop the STARS Program consisted of a set of nine areas, each of which addressed part of the "software problem" and was planned more-or-less autonomously from the others. A set of success factors, in the sense of things that have to happen in order for the STARS Program to be successful, was never identified. There was not then (nor has there ever been) a comprehensible, concrete statement along the lines of: "These are the five things (events, conditions, technical breakthroughs, etc.) that must take place in order for the STARS Program to accomplish its goal."

While the 19 September Program plan does not give an explicit list of critical success factors, it does imply a number of factors including: create valid, reliable, objective and public evaluation criteria; standardize information interfaces; and obtain support from the STARS constituency, including DoD Program Managers and contractors. Any list of factors must be more complete both in its breadth and in its depth since concrete, specific factors are needed for successful Program guidance and assessment. These factors should not only be used to measure progress but they should also be used to assess the role and priority of various STARS activities.

The lack of a clear set of success factors reflects an overall lack of focus of the STARS Program. STARS cannot be everything to everybody. It must try to do a few things well. These things need to be identified and tracked closely. The following is the beginning of a suggested list of marketplace theme-related success factors:

(1) Carefully predict DoD needs in the 1990's.

(2) Carefully predict what the marketplace will supply.

(3) Stimulate market investment in neglected areas.

(4) Build what the marketplace will not supply.

(5) Assess impact of the STARS Program by how well DoD needs are being met.

These, in turn, suggest other success factors at the next level of detail, such as the ones implied by the 19 September Program Plan. One of the early activities must be to examine and expand this list.

4.3.2.5.3 Execution Strategy

The previous Section provided some general guidance and recommendations for getting the STARS Program moving, particularly under a marketplace theme. Successful implementation will require adoption of some changes in the current execution approach, i.e., adoption of five fundamental management precepts, and immediate actions to gain control and produce near-term successes. These actions are necessary regardless of which overall theme or strategy is followed.

Fundamental management precepts. With the theme of fostering and stimulating competitive marketplaces, management of STARS must continually fine tune its strategy to adapt to the evolving needs of its constituency. The suppliers and consumers of tools will need balancing against evolving

needs of DoD as the customer. Programmatic plans and priorities will require adjustments in tactics, schedules, and controls.

There are five precepts by which the STARS program should be managed and tuned to remain responsive to the needs of its constituency:

Precept 1: There should be an annual Strategic Planning Cycle. The purpose of this strategic planning activity should be to assess performance in the prior year, to evaluate the strategy and to incorporate proposed changes.

Precept 2: A STARS Policy for acquisition and ownership of products should beprepared to provide the guidelines for development and distribution of marketplace products. The purpose should be to enumerate policy with respect to planning and review; define types of products to be developed or encouraged; determine ownership of products developed privately, by government, or jointly by IR&D; identify control agents or agencies for STARS-contracted products; and identify control agencies for interfaces, standards, and other definitions.

Precept 3: STARS should create a symbiotic relationship among DoD, industry andacademia. The purpose should be to foster an environment where public and private needs are held in check and balance as the parties work together within the requirements of public law and FAR's. New means of cooperative relationships are needed to stimulate investment while protecting the interests of participating parties.

Precept 4: There should be quarterly reviews of all STARS activities. The purpose should be to ensure that the activities are providing adequate support for the pertinent strategic goals and/or objectives. This review should be conducted by a panel that will ensure that corrective action is taken when technical or policy concerns indicate a deviation from STARS strategy.

Precept 5: Area plans should be approved by the SJPO. Area plans should be tactical ones that show how strategic goal(s) will be addressed. Implementation plans should address how the products resulting from an effort will be installed, inserted into a customer base, and maintained.

Immediate actions. The panel felt it was very important that STARS get into execution quickly and, of course, pursue relevant activities.

The first step should be to appoint a permanent Director at once. This Director must be placed in a situation where success is possible and must be given effective planning and execution authority. This might require programming the STARS budget as an OSD element. The Director must then establish a clear contracting strategy and begin moving money quickly. The panel suggests spending 90% of available funds within six months. After getting the internal house in order, the Director must seek out strong advocates and customers and encourage the Area Teams to do the same.

Critical to stimulating the STARS Program is direct attention to developing plans that lead to incremental products. This will lead to the earlier appearance of results with the valuable side-effect of demonstrating early progress and value. It will also preserve the flexibility to shift plans and schedules in response to newly identified needs or newly available technology.

Incremental product development is almost synonymous with evolutionary prototyping. It is suggested that prototyping be done early and often. It is recognized that this may be incompatible with use of MIL-STD-2167 and may require the development of new contracting approaches. It was considered important not to let these potential problems steer the STARS Program away from a strong committment to a prototyping approach.

The 19 September Program Plan reflects an incremental building approach to the STARS-SEE development. While this is a move in the right direction, it is felt that more is needed. In particular, there is still too much emphasis on early, Government-based definition of the eventual product. Prototyping should be employed to not only assist in designing the STARS-SEEs but should also assist in evolving the definition of their functionality.

4.4 STARS Areas

In this section, each of the STARS areas is analyzed as it was presented in the September 19 *Program Plan and the STARS August Quarterly Briefings*. The intent is to assess how completely each Area's goals, objectives and plans are defined and how well they contribute to meeting the overall Program's goals and objectives.

Each of the Areas has specific goals and is organized into activity areas intended to meet these goals To assess an Area, the general approach was to first map the Area's goals back to the Program's goals, then determine how the Area's activities were grouped to support meeting its goals, and finally consider the Area's intended results in terms of their completeness and their contribution to meeting the Area's goals.

The panel's assessment of each of the Areas is presented in this Section. Prior to these assessments, the Program's goals themselves are discussed. In addition to the current six Areas, the panel considered the two Areas, *Systems and Human Engineering*, that had been distributed across the other Areas subsequent to their original definition at the Raleigh Workshop.

4.4.1 Goals

The 19 September Program Plan specifies a set of ten specific goals. Six are pertinent to technology development; three pertain to the transition of technology into use; and one concerns program assessment.

The ways in which these goals relate to the Program's Mission are not discussed in the document. The goals are, however, essentially identical to those specified in the report produced by the Goals and Objectives Working Group (GOWG). One difference is that whereas the GOWG report lists "develop interfaces between environments" as a separate goal, this goal is included as part of one of the Program Plan's goals. Another difference is the Plan has an explicit goal concerning reusability and application-specific needs---these issues were not spelled out in the GOWG report's statement of goals, but were rather listed as global issues. A final difference is that the plan's program-assessment goal was not stated in the GOWG Report since program assessment is a management goal whereas the GOWG Report dealt exclusively with technical goals.

Therefore, the reduction of the Program's mission to its specific goals can be explained by using the discussion in the GOWG report. It is not recommended that the discussion actually appear in the Plan, only that the GOWG report be made consistent and used as a supporting document.

The goals of the STARS Program emphasize supporting the development of new MCCR software. A possible additional goal is to attend to the problem of "renewing" the mountains of

existing MCCR software. This would involve supporting the enhancement of existing software and the transformation of it into a form amenable to support through use of STARS environments.

4.4.2 Relationship of the Areas to the Program's Goals and to Each Other

4.4.2.1. Areas and Program Goals

The STARS Program is currently divided into six Areas. The relationships of these Areas to the Program's goals, as presented in the 19 September Program Plan, are depicted in Figure 8.

While coverage seems complete, several relationships are missing. First, the discussion of the Areas later in the plan indicates some activities are planned in support of overall Program goals, but that support is not depicted here. For example, the Software Engineering Environment and Methodology Areas plan to develop technology transition mechanisms. Second, some critically necessary relationships are missing, both from this depiction and the plans for the Areas themselves. For example, the Business Practices Area should be planning to support the "reusability and application-specific needs" goal by developing the motivation and policies needed to foster the practice of reusability.

The seemingly random relationship between the Areas and the Program's goals, reinforced in Figure 8, has been a long-standing problem. Primarily, it has led to an inability to justify the suitability of the Program's organization. The diagram suggests two solutions. The less preferable by far would be to restate the goals so that each Area supports achieving all the goals. The preferable solution, compatible with solving some of the relationship flaws noted above, is to capitalize on the fact that there are really two types of goals. First, there are those goals that relate to a specific capability needed for effective support of the software creation and evolution process. For instance, a variety of modern methods, and the ability to select among them, is required. Second, there are goals that pertain to characteristics of the process or the products it produces. For instance, reusability is a characteristic of the Ada software language process. It would seem natural to have each Area responsible for achieving a specificly needed capability while at the same time contributing all of the process and product characteristics.

4.4.2.2. Interconnections

A study of August 1985, Applications Area plans revealed that many area activities should be linked to activities of other areas. Of forty-seven one-way links that we felt probably should be institutionalized, there were none that appeared to be institutionalized. There were six expressly stated links and six weakly stated links. Thirty-five of the one-way links that probably should exist were not stated at all. Some management attention should be brought to bear on this problem.

4.4.3. SEE Area

In this Section, we analyze the Software Engineering Environment (SEE) Area plan presented in the 19 September Plan and the SEE Area activities as presented in the August Quarterly Review. The panel has produced an adjusted plan of action for the SEE Area that addresses the criticisms the panel has found. This plan is presented at the end of the section.

4.4.3.1 SEE Area Overview

For the SEE Area, the 19 September Program Plan discusses the overall STARS Program approach to developing the Program's STARS-SEE products. The plan does not indicate concrete goals and activities that indicate the SEE Area's role in developing these products. It can be inferred that the SEE Area will play a major role and the discussion of the SEE Area here attempts to make

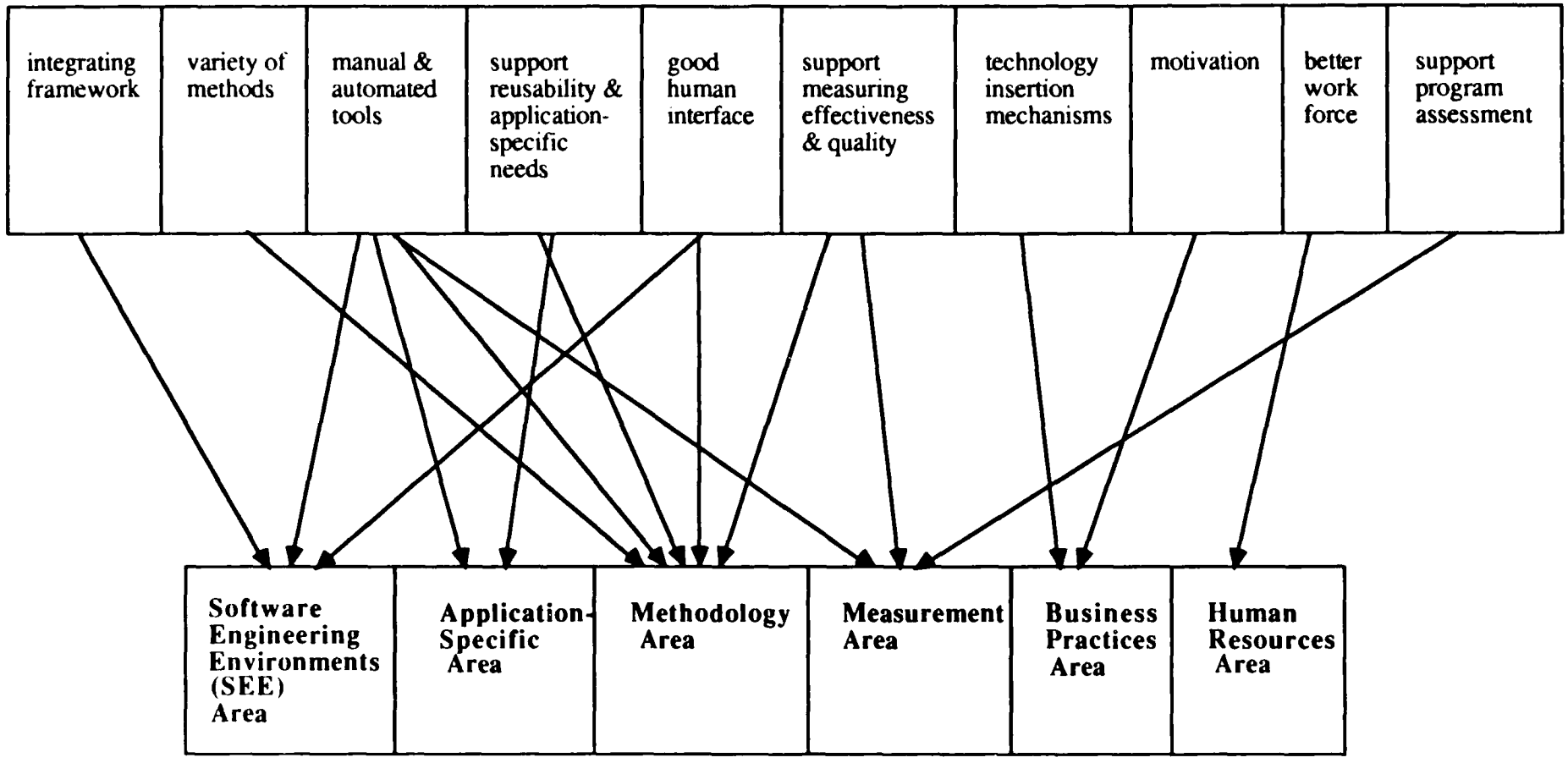

Figure 8. Areas/Goals Relationships

A-123 BSH11/85-123

these inferences for the higher level aspects of this area. The details of activities in this Area are taken from documents prepared by its coordinating team.

The general intent and strategic focus for this area reflect the central role it plays in producing the STARS-SEE products. This area establishes the basis for preparing specific environments in response to recognized needs and does this by producing environment substrates on top of which tools may be easily installed.

The goals for the Area, as inferred from the Program plan, generally support meeting the Program's goals but do need to be more specific about the timing interrelationships between interface development and building of the various concrete products.

The SEE Area's plans are fairly extensively developed because this Area has been actively working since early in the life of the STARS Program. The plans emphasize the delivery of products in the near, medium and long term and the investigation of several fundamental issues. The central, focusing activity concerns the production of the STARS-SEE environments under the guidance of MIL-STD-2167.

There is a potential mismatch between the high-level plans given in the Program Plan and what is actually being done in the SEE Area. This mismatch particularly concerns the architecture of the STARS-SEE environments and the degree to which these environments meet production-quality standards. The high-level plans need to be clarified before it can be decided whether or not a mismatch exists.

4.4.3.2 SEE Area Mission and Goals

The mission for the SEE Area, as it relates to the entire program, is not explicitly stated in the 19 September Program Plan. In the Plan's discussion of the Program's environment development activities, however, two intents for the SEE Area are strongly implied. First, the Area should lay the groundwork for being able to rapidly establish powerful, integrated environments in response to recognized needs. Second, the Area should provide a focal point for activities both inside and outside the Program that contribute to developing this capability.

The mapping of Program goals to goals for the SEE Area can be determined by considering what is actually planned in the SEE Area and determining how these planned activities relate to the Program's and Area's goals. Coverage of the Program's technology development goals was considered good. There are, however, no planned activities that address reusability, since under the current organization all reusability concerns are delegated to the Application-Specific Area.

4.4.3.3 SEE Area Activities and Products

Under the existing SEE Area organization, it is through the STARS-SEE activity that the Area's goals are met. The other SEE Area activities are intended to be supportive of the STARS-SEE activity with a prototyping activity doing short-term prototyping studies, an Advanced Environment Concepts activity taking the longer-range view, and Foundation Studies activities looking at some fundamental issues.

The prototyping activity seems primarily focused on producing near-term, interim results. The Advanced Environment Concepts activity's plan is not well-developed enough to identify its products. The Foundation Studies activity seems to be a collection of relatively arbitrary topics. In short, plans for the activities seem to be incomplete in some cases and the ways in which the STARS-SEE activity is supported by the others seems to be poorly defined.

4.4.3.4 SEE Area Interactions

Interactions within the SEE Area focus on the flow of information to the STARS-SEE activity in support of its environment construction activity. The STARS-SEE activity is also the focal point for interactions with other STARS areas, being primarily the reception point for the tools developed in the other areas but also receiving the definition of methods to be supported from the Methodology Area and suggestions regarding instrumentation from the Measurement Area.

The products of the SEE Area flow into the DoD Community at large. Nothing is said in the Plan about a flow of information or products to the other STARS Areas. The current STARS-SEE activity plans have not explicitly defined any interactions with the other areas for the purpose of affecting the activities in those other areas by the delivery of SEE Area products.

4.4.3.5 SEE Area General Strategy

The general strategy for organizing and carrying out activities in the SEE Area is not discussed in the 19 September Plan. The discussion in the plan of the SEE Area instead addresses the overall strategy for developing the STARS-SEE's.

As the Area is currently functioning, there are several key strategic points. First, the Area's activities are partitioned into four parts. Three of these attend to obtaining near-term, medium-term and long-term results, respectively. The fourth addresses several fundamental issues that affect all of the results Second, all major environment development activities are being carried out by following MIL-STD-2167.

4 4 3.6 SEE Area Specific Strategy

As presented in 19 September 1985 Program plan, the cornerstone of the STARS program is the development of powerful integrated software environments. The strategy for this development comprised the following: (1) Establishing a substrate upon which tools can easily be installed; (2) fostering industry participation while retaining ability to define directions; and (3) Government sponsorship of at least two proof-of-concept substrates and at least two full-capability environments.

While basically sound, this strategy is unclear in several regards. It is unclear how Areas other than the SEE Area will be driven by this strategy. The need for government sponsorship of two full-capability environments is unclear. It is unclear whether the definition of environments is intended to provide a logical structure for problem identification, or a physical structure for construction project definition. The relationship between the framework and the substrate is not clear; the plan's diagrams indicate that the substrate is obtained by adding generic tools to the framework whereas the text indicates that the framework is partially composed of the substrate.

4.4 3.7 Comments Regarding SEE Area

The plan is not as explicit about the goals and activities for the SEE Area as it is for the other areas. For example, there is an organization of activities within the SEE Area that is not presented in the Plan.

This raises the question of whether there is a mismatch between what management wants and what is actually being done in the SEE Area. Before this can be determined, the nature of the development approach being suggested by management needs to be clarified. This involves clarifying the critical concepts, the general nature of near-term results, and the implications of management directions for an environment's architecture. Following this clarification, the extent to which current projects are compatible with management direction can be determined. In particular,

the issues of whether the current projects are fostering the development of multiple environments and developing the general interface requirements prior to implementation can be addressed.

4.4.3.8. An Alternative SEE-Related Strategy

The panel felt that the strategy for the SEE-related activities presented in the 19 September Program Plan was oriented toward building environments as opposed to an orientation toward stimulating the marketplace to provide those environments. The panel, realizing that some environment-building activities are required, developed a strategy that it felt was more consistent with the suggested marketplace theme. A key aspect of this strategy is to shift attention away from developing complete, wide-spectrum environments (at least under Government sponsorship) and toward the production of compatible toolsets. That strategy is explained below. The Panel suggested that STARS consider this strategy.

The strategic model suggested by the panel for the development and acquisition of and portable rehostable toolsets used in the development of portable but application- specific software is based on extensive utilization of the software marketplace. The approach is to interact with the software development marketplace as an intelligent and powerful consumer. In order to stimulate this sector to provide appropriate and sufficient responsiveness, the STARS program must take the following four separate but related actions:

(1) To reduce the risk of commercial participation by demonstrating technical feasibility through the development of necessary prototypes. These will be produced privately and made available privately.

(2) To provide standards and guidelines for the development of tools, both prototypes and production quality, that will be used in the toolsets.

(3) To announce an intention to acquire tools developed under commercial sector support to be used in the toolsets.

(4) To modify government acquisition regulations and propose legislation, if necessary, to allow commercial ownership of most of the products developed under this strategy.

The actual development and acquisition would follow a simple tactical plan with three principal activities. These activities are:

- o First, a small number of contracts (two or three) would be initiated to construct a distributed CAIS kernel using an existing virtual machine (e.g., VMS, UNIX, CMS, MS-DOS, Rational, etc.) as a basis. We call the results of these contracts "backplanes."

- o Second, building upon the resulting backplanes, four to six additional contracts would be initiated to construct prototype generic tools and tool fragments. These prototypes would be hosted on the backplane in much the same manner as hardware circuit boards are inserted into an hardware backplane. This will require standardization beyond that provided CAIS. A core set of typed objects (processes/data files) must be specified.

- o Finally, a larger number of additional contracts would be initiated to construct application-specific prototypes that would also be hosted on the backplanes. Thus, the resulting families of application-specific toolsets would be as compatible as possible since they all use the same underlying model but would only carry the tools that are appropriate to their application domain.

This approach to producing compatible toolsets tuned to various application areas is likely to produce higher quality results, with a shorter delivery time, than the existing STARS SEE strategy.

4.4.4 Methodology Area

The Methodology Area within the STARS Program addresses the problem of providing a variety of software creation and evolution approaches for use on DoD software projects. The overall intent is to broaden both the applicability of the collection of methods available for use on DoD software projects and the extent to which they are actually employed.

4.4.4.1 Methodology Area Mission

The STAR's Methodology Area focuses on the principles, practices and procedures used for the creation and evolution of software. Its scope is broad, encompassing both technical and managerial concerns.

The overall intent is to increase the breadth of the collection of methodologies available to support DoD software projects, the extent of automated support for these methodologies, and the extent of their use throughout the DoD community. Attention is directed in particular to those methodologies supporting the use of the Ada language and software reusability.

4.4.4.2 Methodology Area General Strategy

The Area's strategy is to focus on the problems surrounding the effective use of modern methodologies and let that drive expansion of the collection of available methodologies. The underlying premises are: that current-day methodologies are adequate (but limited); that no single methodology will be sufficient even for an average set of software projects; and that the major inhibitor to effectively using modern methodologies is an inability to identify which methodology to use for a specific project.

According to this strategy, in the mainstream of activity is the development of a capability to choose a methodology, given the needs of a specific project. The two major steps in this choice would be: (1) an initial evaluation of alternatives followed by (2) a selection among those judged to be acceptable. The Methodology Area's activities seek to support both evaluation and selection, particularly through the development of materials that support a heuristic approach.

Through these activities, the requirements for methodologies specific to DoD problems will be identified. These requirements will, in fact, form the basis for evaluation and selection criteria. In developing the requirements, particular attention will be given to supporting the use of the Ada language and software reusability.

Development of the evaluation and selection capabilities will also help identify flaws or incompleteness in the methodologies available today. The Methodology Area will attempt to correct the situation by enhancing existing methodologies when possible, and developing new ones when necessary.

4.4.4.3 Methodology Area Goals

The goals for this Area are:

(1) To develop the capability of evaluating methodologies with the intention of selecting among alternatives.

(2) To identify existing methodologies of particular value for DoD projects and refining them, as needed, to enhance their applicability.

(3) To conduct methodology evaluation experiments.

(4) To develop automated tools supporting various methodologies.

(5) To assure that the STARS-produced environments incorporate the methodology support tools.

(6) To foster widespread use of the methodologies through recommendation, support and active promotion.

These Methodology Area goals primarily support meeting the STARS Program's technical goals. By assuring a wide breadth of coverage for the Program's technical goals, one can assume adequate support for meeting those goals.

There is one flaw however---the Area's aim of developing a methodology selection capability is not reflected in the statement of the Program's goals. This flaw should be corrected by expanding the scope of the Program's goal to "provide a variety of modern methods" to encompass a way of providing the means to select among those methods.

4.4.4.4 Methodology Area Activities, Results and Interactions

The Methodology Area is, in general, adequately structured to meet its goals. The activities are partitioned into four activity areas and an extensive variety of products have been identified for each activity area.

The 19 September Program Plan mentions a few interactions among the activity areas and among the Methodology Area and the other STARS Areas as well as outside the STARS Program itself. The most well defined of these interactions are those outside the Program. The least well-defined are those with the other STARS Areas.

The interactions within the Methodology Area and among it and other STARS activities needs extensive work. In particular, the flow of information and products into the the Methodology Area has not been defined at all.

4.4.4.5 Comments Regarding Methodology Area

In general, the Methodology Area is well constituted. Its goals are reasonable ones that adequately serve to meet the Program's technical goals. Its anticipated activities should provide an adequate basis for useful near-term and long-range results.

Some of the flaws in the definition of this area and its activities have already been noted: the STARS Program's method-oriented goal should reflect the Methodology Area's selection-capability activity and the interactions within the Area and among the Area and other STARS Areas are not sufficiently well defined. In addition, the Area's plans are incomplete. Long-range plans are weak or nonexistent. For the methodology/tool development and the insertion activities, no concrete short-term plans are presented. For the methodology/tool development activity, no coherency or logic is present for the topics identified as those that should be emphasized.

4.4.5 Measurement Area

In the following sections, the Measurement Area is analyzed from two perspectives. First, it is looked at from within the context of a "build-it" approach, in which the objective of the STARS Program is to provide production-quality tools, specifically in the form of the STARS-SEEs. The Measurement Area is then discussed within the context of a marketplace-stimulation approach, in which the objective of the Program is to stimulate investment, competition and innovation within the private sector, with STARS building only that which the marketplace will not provide.

4.4.5.1 The Measurement Area From a Build-It Perspective

The Measurement Program Plan (4 Nov 85) presents a "build-it" strategy for promoting measurement. This has been the approach taken by the Measurement Area from the earliest planning stages of STARS (pre-Raleigh). Even at that point in time, the lack of consistent, interpretable, and useful measures and models was recognized as a problem that cut across all areas. The Measurement Area was intended to fulfill two broad functions. The first was to provide expertise to the other area in identifying measures and in constructing and validating models. The second function was to provide the basis for a quantitative assessment of the impact of the STARS Program. The Measurement Area has maintained continuity with the earlier planning efforts. The most recent Measurement Program Plan includes activities to define measures, develop models and production-quality measurement tools, provide demonstrations of the use of measurement in the software life cycle, and develop the necessary training material and seminars to aid in the technology-insertion process.

Failure to foster use. The biggest problem with the plan for the Measurement Area, as with the entire build-it approach, is that it does not address the fundamental reasons for why measurement and modeling are not commonly applied. Simply building more---whether more measures, more models, more training material---does not address the problem. Much more already exists in terms of models and measures than is ever being used. Clearly, something more fundamental is missing than the lack of technology. That is what the marketplace-stimulation approach addresses in an attempt to provide incentives to apply the existing technology in a way that is meaningful and innovative.

Lack of clear goals for the area. Whether one looks at the 19 September Program plan or at the Measurement Program Plan (4 November 1985), there is a lack of clear, crisp goals for the area. Rather, the goals appear to be so broad as to be meaningless. The STARS Program plan lists two goals: "(1) The development and adoption for use of: quantifiable indices of merit; procedures supporting evaluations and comparisons of software products; and assessment of the processes associated with software development, life cycle evolution, and field use; (2) The development of means for assessing how well the STARS Program is meeting its goal."

The "Goals" section of the Measurement Area plan lists only one very high-level goal -- " to develop measurement technology which can provide the data, models, and information to support software acquisition and software engineering decision-making for better planning and specification, for improving software quality and performance, and for reducing life cycle software costs". Clearly, the goals for the area need to be further decomposed and made more precise.

Lack of interaction with other areas. Another problem is the lack of interaction with the other areas. The plan alludes to such interaction, but there are no concrete plans for carrying it out. If it is to be effective, Measurement cannot exist as an isolated activity. Its original purpose was, and its current one must be, to support the other areas. The attempt to isolate measurement as a separate activity is probably the reason for the lack of clear-cut goals as discussed above; without being tied to the other areas, it is trying to do everything.

The suggested approach to assessing impact of STARS is confused. Both under the build-it approach and under the marketplace-stimulation approach, a very important function of the Measurement Area is to assess the impact of the STARS Program. This needs to be given far more thought than it has received to date. The approach mentioned in the Measurement Area Plan, which is to compare projects before and after the infusion of STARS-developed technology, is a confused one, with time being the confusing factor. Instead, STARS and non-STARS projects should be compared at similar points in time.

The Measurement Area plan is disjoint. As a final note, the plan is disjoint, with no clear relationship between its first and second halves. For example, the first part (under "Scope") mentions a framework for characterizing MCCR systems in terms of eight dimensions but that framework is not mentioned again. There are planned projects mentioned under "Scope" that do not appear later in the "Approach" Section.

4.4.5.3 An Analysis of the Measurement Area From a Marketplace-Stimulation Perspective

The current Measurement Area plan can be summarized by pointing out that there are useful and needed activities in the plan, especially those involved in providing standard definitions for various measures and in developing a central database of measurement data. Activities such as tool building, model development and calibration, and the development of training materials are unlikely to increase the use of quantitative techniques because the necessary incentives are missing. The marketplace-stimulation theme has been suggested as a way of providing these incentives in the following section. The Measurement Area is analyzed from that perspective section.

Measurement can play a pivotal role in the marketplace-stimulation strategy because, to the extent that DoD requirements can be expressed and evaluated quantitatively, they become objective and precise. The more vague the characteristic being specified, the more important it is that it be tied to something measurable. For example, a seemingly fuzzy characteristic such as "easy to use" can be precisely specified by requiring that a representative sample of users be able to accomplish a given task within a given amount of time with fewer than a given number of errors.

The Measurement Area can play an essential role in the Program by ensuring consistency and uniqueness among the measurement activities in the various areas. It is essential that measures such as lines of code be defined and calculated in a consistent way. Progress in software measurement has suffered greatly from the lack of such continuity. The Measurement Area can also serve a useful function in assessing the impact of the STARS Program. Exactly how this will be done, however, requires a further study.

4.4.6 Application Specific Area

The following findings are derived from the August 1985 Quarterly Review documents. They reflect panel concerns and should encourage management attention to determine if the concerns are justified and whether they would be alleviated or aggrevated by FY86 plans.

The panel found that virtually all responsibility for supporting reusability of software resides in the Application-Specific Area. There are aspects of reusability that require attention from the other areas as well. In particular, an opportunity is being missed not to strongly direct the SEE Area toward reusability. To evolve the STARS-SEE's as planned by management, the SEE will have to develop a good deal of reusability-supporting technology.

Some support for almost all high level STARS Program goals is provided by this Area. Some of the goals, however, are only weakly supported. The goal of supporting program assessment currently appears unaddressed. The goals of understanding and providing good human interfaces is supported as a minor point in only one activity, D5--ABICS.

The activities of this Area are largely unrelated to each other and are disconnected from the other STARS Areas. This lack of internal interrelationships is not surprising and may be justified by the need to demonstrate STARS-supported technology in diverse applications. There are some common aspects to the activities but it is not clear if there is one activity that will coalesce the common experiences and adequately transfer the new knowledge. The schedule, for example, of the "Reusability Guidebook" does not appear to be taking as input the experience gained in the other projects. It is very important that the links of this area to other STARS areas and other Programs and activities be institutionalized.

For example, the connections of application-specific activities with the SEE area are unclear. Another example is that the relationship with the Business Practices Area is not well established. The Application Specific Area should work with the Business Practices Area to identify application areas for which unique business practices will have to be developed. The Business Practices Team should be responsible for developing these.

An activity from which DoD could benefit a great deal that would naturally fall within this area would be the development or encouragement of a standard family of real-time kernels. The strategy used could be similar to the proposal herein for the SEE area (see Section 4.4.3.8). Another activity that has been ignored is the creation of a process whereby new application areas are brought into the new STARS-inspired, DoD practice.

4.4.6.1 Application Specific Area Goals and Objectives

According to the September 19 Plan and the August 1985 quarterly review briefings, the Application Specific Area's goals and objectives support all the Program goals except "motiviation" and program assessment. The rationale for the objective of developing specialized simulators appears to be a bottom-up rationalization. It is unclear why the common library effort is here rather than in the SEE Area. The concept of technology transition by "spreading the word" is not well thought out. Otherwise, the objectives are reasonable. The overriding problem is the nonexistence of links to other areas, especially the SEE Area.

4.4.6.2 Application Specific Area Objectives, Activities and Products

All objectives are supported to some extent by activities. The panel does not understand how "spread the word" is supported nor what the "conversion to Ada" objective supports. We also do not see evidence of the realization of the connection between this objective and similar activities in the WIS program. The activities are largely unrelated, but that is reasonable for this area. There should, however, be an effort at extracting the common experience derived from these activities. We also feel that the objective of developing reusable run-time parts would be better supported by an activity for demonstrating a family of (or a generic) standard real-time kernels.

4.4.7 Business Practices Area

The objective of the Business Practices Area as stated in the Quarterly Review of November 1985 is to: "Develop and introduce concepts, tools and techniques to improve software acquisition practices across program phases. Specifically: software maturity and reuse; expert management system and contract documentation; estimating and control metrics; DoD software standards; and technical and engineering management support."

The funding profile is $1.7M in FY86, $5.3M in FY87, and $14.3M in FY88 for the following tasks: software maturity and system called SWAPX (C2); estimating and control metrics (C3); standards (C4); support called TEMS (C5)

The DoD has as its most effective mechanism for technology development and insertion, its behavior in the industrial sector as an intelligent consumer. The original purpose of the Business Practices Area, as presented at the initial public review held at Raleigh, was:

(1) To develop the body of knowledge necessary for the DoD to act in the role of intelligent consumer.

(2) To develop a suite of program management tools to provide consistency and support across both program phases as well as across programs and application areas.

(3) To propose changes to DoD regulations, practices and standards appropriate to enhancingthe DoD position in the business environment. Thus, the Business Practices Area should be concerned with all the marketplace issues described in Section 4.3.2.

However, the Business Practices Area task has narrowed in focus, as stated above, to the acquisition of software and eliminated any emphasis on developing the knowledge to improve and exploit the DoD position in the commercial sector.

The Business Practices Area has two subtasks, maturity (C1) and metrics (C2). These subtasks are direct linkages to the Measurement Area yet there is no such linkage described in the Business Practices Area plan.

No program management plan is in place, although it is proposed that the support contractor aid in the development of one by third quarter FY86. It is apparent that developing a management plan in this manner will lead to a justification of subtasks C1/C4. While it is critical that some work be performed toward meeting program objectives, there should be some concern about the subtasks driving the development of the plan.

There is no linkage to other task areas, with the possible exception of the measurement area. STARS must exploit the fact that the Business Practices Area is the most powerful tool the STARS program has in its mission the insertion of appropriate software technology into the DoD software development community.

4.4.7.1 Recommendations for Business Practices Area

The focus of the Business Practices Area should be broader. Specifically, the area should include:

(1) Developing cost/benefit templates for other technical areas with respect to commercial/DoD marketplace effects

(2) Developing an understanding of the dynamics of the software marketplace

(3) Understanding the impact of DoD standards, their feasibility and cost effectiveness as well as the tradeoff between inhibition of technology insertion and logistical needs

(4) Understanding future DoD software needs and likely commercially available technology

In addition, the Business Practices Area should investigate possible altertion of FAR, DFAR and any other applicable regulations and laws. It should also work with the Human Resources Area to attempt to alter the practices of Program managers in order to effect the change of DoD into an intelligent consumer.

The Area should closely integrate its activities, planned and ongoing, with the other areas.

The Area's plan should be refined before any tools are developed. In particular, the content of the knowledge bases will most likely change once an understanding of the DoD role in the commercial sector has been developed.

The Business Practices Area team should be populated with industrially knowledgeable members including lawyers and private sector executives familar with the DoD and the various procurement and acquisition strategies.

It should be recognized that the most important subtask in the STARS effort for technology insertion, i.e., getting the STARS tools used, is the Business Practices Area. In addition, it is the most difficult area in which to accomplish anything significant. The funding does not reflect this and should be increased.

4.4.8 Human Resources Area

The Human Resources Area's goals derive mainly from three STARS Program goals---better work force, technology insertion, and measurement. Measurement of personnel is an important, but sometimes overlooked, aspect. The efforts in this area are divided into three activities. The first two try to establish the size of the current work force and what should it be in the 1990's. And the third concerns itself with development of material and technology for education and training.

If STARS is to influence the composition of the work force in the early 1990's, it needs to know what to aim at before 1988. Some progress could be made now based on the general need for upgrading that work force.

The actions required to impact the work force are not well defined. Some of this is understandable since the requirements are not yet established. But the possibilities and their expected costs and effects should be enumerated. This is an area where the costs are not well known and an awareness of what would be reasonable is needed immediately.

The lack of a measurement emphasis on individuals or organizations could undermine future attempts to inspire improvement and competence through acquisition requirements and evaluations. CAI is an area ripe for DoD benefit from the standardization of such things as authoring languages/systems.

4.4.8.1 Recommendations for Human Resources Area

Plans in this area are too poorly developed for present implementation. Rough estimates of the situation and future requirements should be made soon and then refined as better data are developed. Alternative actions should be laid out in some depth so that their costs, difficulties and impacts can be understood.

These in turn should be used to establish out-year budgets for this Area on a rational basis. Possibly this area should have significantly more money than it is now budgeted, but this is difficult to assess now because possible future actions are so nebulous.

The Ada and STARS Programs need to establish their Human Resources-related boundaries, and the SEI needs to coordinate with them. For example, STARS funds might help buy the rights to existing curricula for inclusion into the SEI master curriculum.

Short or mid-term results such as scholarship programs, career path recommendations, rapid concurrent adaption of the SEI curriculum for industry and Government use, even seminars for

government employees might be beneficial. These measures would also have the effect of being visible STARS results.

STARS should not be a "don't rock the boat" progam. Present Human Resources Area plans, possibly because of their nebulousness and the low area budget, appear to lack boldness. However, a low budget may necessitate cleverness. As a possible example of an innovative move, consider (in line with the marketplace theme for STARS) the development of meaningful, operational "specifications" for the human resources DoD acquires on contracts. This would include certification testing of the various types of software-related personnel and topic testing such as knowledge of DoD-STD-2167 or Ada.

4.4.9 Systems: A Lost Area

The panel felt the content of this original STARS area was of increasing importance to DoD and should be adequately covered. A new "Systems" initiative/program bridging STARS and VHSIC may be appropriate. In any case, STARS should include software related systems concerns. For example, the emphasis on reliability/fault tolerance in the original Systems area should not be lost.

Further, there is evidence that industry supports the idea that DoD should consider a systems approach to the MCCR engineering problem. For examples, see the CODSIA reports.

4.4.10 Human Engineering Area

Human Engineering was one of nine task areas at the time of the Raleigh workshop, giving it considerably more visibility that it now has within the STARS Program. As originally envisioned, it was broad in its concerns, covering not only human engineering of the software support environment (including methods as well as tools) but also human engineering of MCCR systems for the end user. The basic plan for the Human Engineering area was endorsed and refined at Raleigh and provided a solid starting point for more detailed planning.

Human Engineering as a separate area disappeared from the STARS Program in 1984. There is now a tri-service committee addressing human engineering within the SEE Area, although it seems to have been largely ignored in all earlier plannin). The Methodology Area has paid lip service to including Human Engineering methodologies but has done nothing concrete to date nor does it currently employ members with the required expertise.

4 4.10.1 Technical and Managerial Recommendations for Human Engineering Area

We recommend that the Human Engineering Area should be reinstated to focus on the technical issues involved in specifying, evaluating, and selecting products on the basis of usability (and not on building production-quality tools).

The strategy for Human Engineering (as part of the strategy of the STARS Program as a whole) should involve being very clear about the desired end products and how they will be evaluated. As much as possible, the participation of high-caliber people with human-factors experience should be solicited and encouraged.

STARS should take steps to achieve much greater visibility and support among all of its constituents. The Raleigh workshop served to focus the attention of several nationally-known human-factors experts on the STARS Program. The interest and involvement of people with these qualifications can result in enormous contributions to the STARS Program. The reliance on government committees, particularly as vehicles for planning, has clearly not been successful.

5.0 SYNOPSIS OF RECOMMENDATIONS

The panel has identified and discussed in the preceding parts of this report a number of managerial, thematic, and strategic recommendations for STARS. The primary recommendations are summarized in this Section, along with a short rationale for each.

The most crucial requirement is to identify, hire, and empower a strong, permanent Director and to establish a tenable political situation for that Director. The current contention between OSD and the Joint Logistics Commanders (JLC's) over who is in control of the Program must be resolved quickly if the Program is to be saved. The Director must institute top-down planning and control. In order to do this, a hierarchical organization of dedicated billets, responsible to the Director, must be formed. There are many acceptable devices that DoD can use to accomplish this, but the end result must be that review and control over line and non-line personnel rest with dedicated STARS management. The STARS Director must also be given effective spending and contracting authority. A check-and-balance, distributed, consensus-oriented approach to spending authority is inappropriate here.

The panel felt strongly that STARS should adopt, and consistently operate within, a theme of marketplace stimulation. STARS needs to manipulate the demand side of the marketplace by turning DoD into an intelligent customer for software technology and for mission critical software. STARS must also stimulate the supply side of the marketplace by creating conditions conducive to a community competing to supply software engineering tools, methods, training, service, MCCR software components, and the other artifacts and practices STARS and others recognize as critical to meeting DoD's MCCR software requirements. In addition, STARS needs to help drive the suppliers of that software to a more efficient state of practice.

This is an inherently more difficult theme than one in which STARS simply pays for the development of new tools, systems, and related technology without considering how these developments will be used or how they will reduce costs in the future. Every project undertaken by STARS will face the difficult decision of how much STARS must fund in order to ensure that a given capability will appear in the marketplace at the appropriate time. Must feasibility demonstration be performed? Must the value of a proposed product to its potential users be demonstrated? What will the measures of value be? How will these measures be made? Must certain items be produced or purchased? What standards are required and when? What new business practices within DoD are needed to establish the consumer or producer sides of the marketplace? These kinds of decisions will require close cooperation with industry and will also necessitate understanding of a wide range of political, entrepreneurial, and technical issues from within the STARS leadership.

The panel also recommends that STARS management take a new look at the set of areas and the relative emphasis the program places in those areas. The panel recommends in particular that the lost areas of Human Engineering and Systems be reconstituted in some way. It may be that there should be components of these two concerns added to some or all current areas. The committee definitely felt that linkages between the Measurement Area and the other areas must be very quickly and strongly established or that other steps be taken to assure concentrated attention to measurement issues within each of the areas.

Having reviewed the areas and their relative levels of emphasis, STARS Management should review the constitution of the area teams and repeat this review periodically. The focus of the teams should be changed from a management to a technical orientation because management should be handled at higher levels. The teams should then be made to evolve as the needs of the Program change. For example, it may be that as technical goals are achieved, a team might be oriented toward inserting new technology into the Services instead of developing the technology. Different people will be required as needs change.

The panel felt that measurable goals, objectives and success factors are definable for STARS and that defining and using them is critical to the success of the Program. These goals, objectives and success factors should be established at designated organizational levels, and their success or failure frequently monitored.

The panel's final strategic recommendation is that STARS management gives immediate attention to establishing and cultivating customers, advocates, and links to other programs. An important supporting tactic is to move toward early, demonstrably beneficial, results.

6.0 CONCLUSION

The results of the September-October STARS Program Assessment are that the overall goals of STARS are important and sound and that the September 19 Plan is a reasonable starting point for further development of the Program. There are serious, but solvable, organizational and management problems. A new emphasis on market exploitation and the alteration of DoD's practices as a customer for software should be established. The Program's plans should be executed quickly so that early results will occur. Close relationships with STARS constituency and the Program's advocates should be cultivated as soon as possible. Finally, a review and reorientation of the technical areas and teams needs to be done.

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APPENDIX A

STARS PROGRAM CONSTITUENCIES

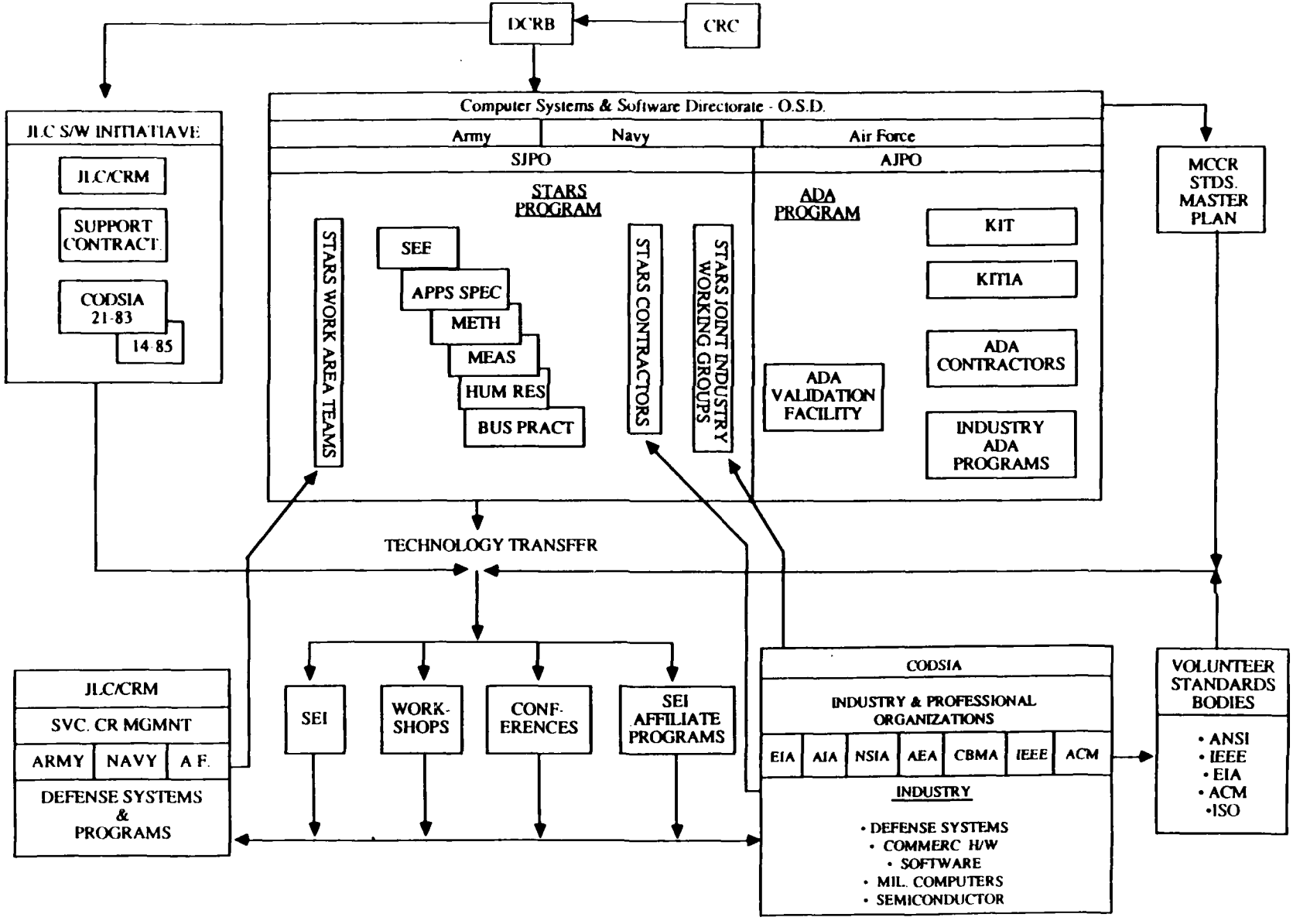

Figure 7. Technology Transfer Relationships and External Constituents

APPENDIX A

This appendix provides a detailed explanation of the STARS Program's constituencies as depicted in Figure 7.

A. DCRB/CRC

The DCRB is responsible for implementing MCCR acquisitions policy, and as such represents the management level personnel directly guiding (and/or enforcing) use of STARS-generated technology and policy. This board also is the top level group capable of granting waivers to established acquisition policy.

The DCRB is shown, in Figure 7, with line relationships to Computer Systems and Software Directorate (its chairman), and to the JLC Software Initiative who has a representative on the DCRB. The DCRB is at the "top of the figure" because of its heavy representation of Assistant Secretaries and star-rank officers.

B JLC Software Initiative

This initiative area is most widely known for its standards producing efforts (MIL-STD's originally known as SDS and SQS, now registered as DoD-STDS-2167 and 2168). It is also engaged in producing joint service policy, business practices, methodology (specifically applied to software acquisiton), measurement (as applied to software quality), and management practices. Some of the products of the software standards project include:

- Joint Regulation on Computer Resource Management in Defense Systems
- Software Development Standard (DoD-STD-2167)
- Software Quality (DoD-STD-2168)
- Configuration Management (MIL-STD-483A)
- Specification Practices (MIL-STD-490A)

The JLC effort attracted industry attention and participation almost as intensively as the Ada program attracted professional and academic attention and participation. The industry-wide participation continues at present at a high level; the September 1985 EIA Annual G-34 Panel Workshop had eight large panels on related issues. The large degree of participative attention had a major impact on the development of the Initiative's products.

The products have a strong coupling to the STARS areas. Particularly in technology-sensitive areas, such as Software Practices, Methodologies and Support Environments, synergism between this effort and STARS would be beneficial (particularly with the already in-place working relationship with industry).

Interfaces with STARS work areas have been suggested by JLC Initiative industry participants:

(1) SDS Issue 5: System engineering to software development interface (Methodology, SEE, Business Practices Areas)

(2) SDS Issue 8: Ada design and coding standard (Methodology Area)

(3) SDS Issue 13: Design Methodologies (Methodology Area)

(4) SDS Issue 26: Reusable and commercial software (Methodology, Business Practices, and SEE Areas)

(5) SDS Issue 43: Automation of MIL-STD-2167 Documentation (SEE Area)

(6) SDS Issues 56-60: Artificial Intelligence software development in MIL-STD-2167 context (Applications Specific Area)

The "output" of the JLC Software Initiative, insofar as STARS is concerned, is technology to be transferred to the constituent community, as represented in the figure. There is no predefined path for the JLC effort to receive benefit from STARS at present.

C. STARS Joint Program Office

1. STARS Area teams

The STARS Areas presently receive direction from the managing DoD components. They act to manage the SJPO area effort (presumably contractor produced) that will provide technology to be transferred as represented in the figure.

2. STARS Area contractors

The contractors perform the work required to meet the STARS Area goals, as directed primarily by the STARS Area teams. Being members of industry, these constituents are also members of their individual employing organizations (who review the workers), and the employers are members of respective industry associations. The workers are likely to also be involved with professional societies such as IEEE and ACM and thus be influenced by colleagues (on a personal basis) as well as management (cooperatively interfacing with management of other industrial concerns).

The contractors, furthermore, derive the basis for their technology from industry (and academia). They incorporate ideas from their staffs and IR&D efforts, and integrate them with ideas from published sources, trade sources, and staff colleagues.

3. STARS/Industry "Joint Working Group"

Joint SJPO/Industry efforts have occurred in working groups, such as the 1985 NSIA San Diego Conference, and the 1984 and 1985 EIA Annual Workshop SEE Area panels. These represent non-sponsored opportunities to interact, both on a technology development plan and on a management and practices plan. (This topic does not refer to the STARS sponsored workshops, which are listed under "Technology Transfer Constituents".)

D. Technology Transfer Constituencies

This category includes interfacing parties which derive benefit from the STARS, Ada JLC Software Initiative, and Industry/Academia Programs.

1 Software Engineering Institute

The SEI is chartered to transfer technology developed by the STARS program to Industry and the Services. One mechanism which will be used by the SEI is their "Industry Affiliates" program, wherein Industry members serve in temporary staff positions at the SEI.

2 DoD/Industry Workshops

STARS sponsored joint workshops function as an interface point where STARS technology is disclosed to industry.

3 Conferences

Conferences are sponsored by several groups; the Industry Associations and the DoD respectively sponsored portions of the "San Diego" conferences in Spring 1985; and professional groups such as IEEE and ACM sponsor conferences with relevant sessions.

4. Technology Development Constituencies

This category includes constituents which develop technology to be incorporated by STARS and the STARS contractors.

(1) DoD Working Groups

(2) DoD Industry Workshops

(3) Industry Working Groups

(4) Industry and Professional Organizations

(5) Industry

(6) Industry (Private) Consortia

(7) Academia

(8) DoD Component Laboratories

(9) DoD Defense Programs

5. Standards Community Constituents

6. DoD Constituents

(1) Service entities participating in STARS

(2) Service entity consumers who might be STARS technology users

7. ADA Joint Program Office

This office sponsors five activities which provide technology which will be transferred to external constituents (and to the STARS program):

(1) KIT/KITIA: These organizations have defined a set of tool builder (environment user interfaces to kernel services.

(2) Ada Contractors: These entities are providing Ada compilers, tool products, and environment products.

(3) Industry Ada Programs: A frequent contributor to the technology base for software is software IR&D. These funds are often used to develop company-specific tools and tool sets for future use on projects for the internal DoD (constituent) users.

(4) Ada Validation Facility: This facility's greatest contribution is in the stabilization of the Ada language, and the application of such stabilizing technology to other areas (i.e., environment and tool standard interfaces).

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